Chapter 8: Lake Okeechobee Watershed Protection Program Annual Update

Bruce Sharfstein, Joyce Zhang and Lesley Bertolotti

Contributors: Michael Baranski, Patricia Burke, Orlando Diaz, Therese East, Eric Gonzalez, Charles Hanlon, R. Thomas James, Alyssa Jordan[1], Damon Meiers, Cheol Mo, Kim O'Dell, Steffany Olson, Amy Peters, Andrew Rodusky and Odi Villapando

SUMMARY

Lake Okeechobee means "big water" in the Seminole Indian language, an appropriate name for a water body whose opposite shore cannot be seen from the water's edge. With a surface area of 730 square miles, it is the largest lake in the southeastern United States. Despite its impressive size, the lake is shallow, with an average depth of only 9 feet. Lake Okeechobee and its wetlands are at the center of a much larger watershed, the Greater Everglades, that stretches from the Kissimmee River through the Everglades and finally into Florida Bay. Lake Okeechobee is also a key component of South Florida's water supply and flood control systems.

Notably, Lake Okeechobee provides natural habitat for fish, wading birds, and other wildlife, and it supplies essential water for people, farms and the environment. The lake also provides flood protection, attracts boating and recreation enthusiasts from around the world, and is home to sport and commercial fisheries.

Lake Okeechobee has been subject to three long-term effects: (1) excessive total phosphorus (TP) loads, (2) extreme water level fluctuations, and (3) rapid spread of exotic and nuisance plants in the littoral zone. Despite these influences, Lake Okeechobee continues to be a vital freshwater resource for South Florida, with irreplaceable natural and community values. The South Florida Water Management District (District or SFWMD), Florida Department of Environmental Protection (FDEP), and Florida Department of Agriculture and Consumer Services (FDACS), work cooperatively with the United States Army Corps of Engineers (USACE) and other federal agencies, Florida Fish and Wildlife Conservation Commission (FWC), local governments, and other stakeholders to address these interconnected issues in order

[1] Florida Fish and Wildlife Conservation Commission, Vero Beach, FL

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to rehabilitate the lake and enhance the ecosystem and the services it provides, while maintaining other societal functions such as water supply and flood control.

For more than two decades, restoration efforts have been under way to improve the water quality and hydrology of the Lake Okeechobee Watershed through implementation of a suite of projects and programs. The nutrient reductions due to the dairy buyout, FDEP dairy technology-based rule, and other early initiatives made positive impact for the first several years, but leveled-off in the 1990s. As a result, in 2000, the Florida legislature passed the Lake Okeechobee Protection Act (LOPA), which requires the coordinating agencies—the District, FDACS, and FDEP—to work together to reduce TP loading and control exotic species. The LOPA was amended in 2007 to expand restoration efforts to include the St. Lucie and Caloosahatchee River Watersheds, and is now called the Northern Everglades and Estuaries Protection Program (NEEPP) [Section 373.4595, Florida Statutes (F.S.)]. The Lake Okeechobee Watershed Protection Plan (LOWPP) is required under the NEEPP, which promotes a comprehensive, interconnected watershed approach to protecting the lake and its downstream estuaries—Caloosahatchee and St. Lucie. It is a cooperative effort between the District, FDEP, and FDACS.

The NEEPP requires annual progress reports and three-year evaluations of the LOWPP. This chapter of the *2015 South Florida Environmental Report* (SFER) – *Volume I* provides the Water Year 2014 (WY2014) (May 1, 2013–April 30, 2014) status of the Lake Okeechobee Watershed Protection Program, and fulfills the annual reporting requirements of NEEPP for the LOWPP. It includes updates on projects and programs being implemented to help address water quality and quantity issues affecting Lake Okeechobee, water quality conditions in the lake and its watershed, and lake ecology. A cross-reference list for NEEPP reporting is provided in Appendix 1-6 of this volume, and more information on the Kissimmee Chain of Lakes and the Kissimmee River and exotic species status in South Florida is presented in Chapters 9 and 7 of this volume, respectively.

WATERSHED UPDATE

A summary of watershed activities and findings is presented below:

1. Numerous efforts have been conducted under the Lake Okeechobee Watershed Construction Project, including the (1) start-up operation of the Lakeside Ranch Stormwater Treatment Area (STA) Phase I construction; (2) continued operation of a pilot-scale STA in Taylor Creek; (3) preparation for operation of a pilot-scale STA in Nubbin Slough; (4) expansion of the Dispersed Water Management (DWM) Program to negotiate for additional NE-PES projects and construction of the Nicodemus Slough Project, which will provide approximately 34,000 ac-ft of storage annually; (5) continuation of the last major phases of the Kissimmee River Restoration Project; (6) expansion of hybrid wetland treatment technology (HWTT), which represents a combination of chemical and wetland treatment technologies to remove TP at sub-basin and farm scales; (7) initiation of the Floating Aquatic Vegetative Tilling project; and (8) completion and adoption of the FDEP's Lake Okeechobee Basin Management Action Plan (BMAP).
2. Fifteen research, modeling, and assessment projects were initiated, continued, or completed in WY2014, and two are anticipated to begin in WY2015. The competed activities included (1) nutrient budget analysis for contributing basins to Lake Tohopekaliga and East Lake Tohopekaliga; (2) recalibration of Lake Okeechobee Water Quality Model; (3) initiation of the Florida apple snail (*Pomacea paludosa*) stocking study; (4) evaluation of emergent vegetation decomposition and nutrient cycling rates; (5) completion of a three-year study on Permeable Reactive Barrier Technology; and (6) evaluation of several alternative treatment technologies and products to remove phosphorus.

3. In WY2014, TP load to the lake from all drainage basins was 609 metric tons (mt) including 35 mt from atmospheric deposition. This was 7 percent more than the previous water year and is attributable to the 31 percent higher flow; primarily from the northern basins. Indian Prairie Sub-watershed contributed 22 percent of the TP load and 17 percent discharge, with 8 percent drainage area. The Taylor Creek/Nubbin Slough Sub-watershed contributed 19 percent TP load and 7 percent discharge, with 6 percent drainage area, and Fisheating Creek Sub-watershed contributed 18 percent of the TP load and 14 percent discharge, with 9 percent drainage area.
4. The highest sub-watershed unit area load (UAL) of TP came from the Taylor Creek/Nubbin Slough Sub-watershed [1.20 pounds per acre per year (lb/ac/yr)], followed by the Indian Prairie Sub-watershed (0.99 lb/ac/yr) and Fisheating Creek Sub-watershed (0.71 lb/ac/yr). In terms of flow-weighted mean (FWM) TP concentrations, the Taylor Creek/Nubbin Slough Sub-watershed had the highest value [457 micrograms per liter (µg/L, or parts per billion (ppb)], followed by the combined East, West, and South Lake Okeechobee Sub-watershed (210 ppb) and Fisheating Creek Sub-watershed (207 ppb).
5. The current five-year moving average (WY2010–WY2014) TP load from all drainage basins (407 mt) and atmospheric deposition (35 mt) was 442 mt, which is about 302 mt greater than the 140 metric tons per year (mt/yr) Total Maximum Daily Load (TMDL) for the lake.
6. In-lake TP concentrations declined from a high of 233 ppb in WY2005 to 93 ppb in WY2012. In WY2014, TP concentration was 118 ppb, which is a 5 percent decrease as compared to the WY2013 value of 124 ppb. The current five-year moving (WY2010–WY2014) average TP concentration is 115 ppb which is within the pre-hurricane (pre-2004) range.
7. Total nitrogen (TN) load to the lake from all drainage basins (5,517 mt) and atmospheric deposition (1,233 mt) was 6,750 mt in WY2014. The Indian Prairie, Upper Kissimmee, and Fisheating Creek sub-watersheds contributed the largest TN loads to the lake. The Indian Prairie, Fisheating Creek, and Taylor Creek/Nubbin Slough sub-watersheds displayed the highest UAL of TN (in lb/ac/yr). The combined East, West, and South Lake Okeechobee, Indian Prairie, and Taylor Creek/Nubbin Slough sub-watersheds had the highest FWM TN concentrations.

The surface water flow to Lake Okeechobee in WY2014 was 2.828 million acre-feet (ac-ft), or about 3,487 million cubic meters (m^3), which is 31 percent higher than the WY2013 value of 2.152 million ac-ft, or about 2,653 million m^3. Lake Okeechobee began the water year at an elevation of 13.44 ft (4.10 m) National Geodetic Vertical Datum of 1929 (NGVD), which placed water levels in the Low Lake Management Sub-Band. Regulatory discharges from the lake to the estuaries were made until October 21, 2013 based on 2008 LORS schedule (SFWMD, 2010). These discharges were primarily to the Caloosahatchee River, followed by the St. Lucie Estuary as well as south through the S351, S352 and S353 structures. After October 21, 2013 a combination of base flow and regulatory releases to the Water Conservation Areas (WCAs) (via the Everglades Stormwater Treatment Areas) and some pulse releases to the estuaries were made. Lake stage increased to 16.05 feet (ft) (4.89 m) National Geodetic Vertical Datum (NGVD) by August 10, 2013 and remained high until October 2013. At that point, stage began to decline due to drier than average rainfall conditions. Water levels ended on April 30, 2014 at a stage of 13.07 ft (3.98 m) NGVD. Detailed information on regional hydrology during WY2014 is presented in Chapter 2 of this volume.

ECOLOGY UPDATE

Submerged aquatic vegetation (SAV) in Lake Okeechobee decreased this year to a total coverage of 33,854 acres (ac) (13,700 hectares, or ha) as compared to 47,692 ac (19,300 ha) the previous year. Coverage by the macroalga *Chara* spp. decreased from 23,475 ac (9,500 ha) last year to 8,402 ac (3,400 ha) this year. Vascular SAV accounted for more than 80 percent of the total SAV acreage. These changes may be the result of a rapid rise in lake levels just prior to the beginning of the annual SAV monitoring effort and as such, it is unclear whether they represent a real loss in SAV coverage or reflect equipment limitations which prevented sampling at some deeper sites that may have contained plants. Despite the decline in measured SAV acreage, the lake appears to be maintaining a healthy SAV community and winter and spring sentinel sampling indicate the continued persistence of healthy beds at many locations. The trend of SAV being replaced by spike rush (*Eleocharis* spp.) and other emergent vegetation in previously open water nearshore areas, especially in the southern bays appears to be continuing. Based on results from our sentinel emergent aquatic vegetation (EAV) sites, generally drier marsh conditions are resulting in the continued spread of cattail (*Typha* spp.) and woody vegetation in the upper marsh. Several exotic invasive species also appear to be gaining ground as a result of the generally lower lake levels; especially since limited funding has been available for ongoing control efforts. It is unclear what these shifts in the areal coverage of emergent vegetation, vascular SAV and non-vascular SAV are having on habitat values in the littoral and nearshore zones of Lake Okeechobee, although it is clear that conditions are substantially better than they were during the generally higher lake stages that characterized the mid to late 1990s, or in the years immediately following the 2004 and 2005 hurricanes.

Algal bloom activity increased somewhat in WY2014 as compared to WY2013, although it remains well below the levels encountered immediately following the hurricane years of the mid-2000s. A new satellite imagery based bloom monitoring method that would provide more comprehensive information on the spatial and temporal distribution of bloom occurrence, which has proven to be quite successful in a number of central and north Florida lakes, is currently being groundtruthed for possible use on Lake Okeechobee.

The Lake Okeechobee fishery continues to be in good condition and both nearshore and pelagic zone sport fish and forage fish populations continue to recover from the effects of the hurricanes of 2004 and 2005. Overall, values for most species were not as high as they were in 2010, when the fishery appeared to peak, but remain comparable to historical pre-hurricane results. The black crappie (*Pomoxis nigromaculatus*) population, whose recovery has lagged relative to other important lake species, appears to be stable with continued good population values and size class distribution.

Wading bird utilization of the lake for foraging declined from last year activity. Foraging activity peaked early in the season, but fell off and never recovered after a relatively large reversal in lake stage in January. Full results for nesting success are still being compiled and will be available in the annual South Florida Wading Bird Report (SFWMD, 2014).

INTRODUCTION

Lake Okeechobee (located at 27^o North latitude and 81^o West longitude) has a surface area of 445,560 acres (ac) [1,800 square kilometers (km^2)], and is extremely shallow with a mean depth of 9 feet (ft) [2.7 meters (m)] and maximal depth of 12.1 ft (3.7 m) for the past 10 years. The lake is a central part of the interconnected South Florida aquatic ecosystem and the United States Army Corps of Engineers (USACE) regional flood control project. Lake Okeechobee provides numerous services to diverse users with tremendous economic interest in its health and fate. The lake is the primary water supply for the Okeechobee Utility Authority and the backup water supply for much of South Florida. It supports multimillion-dollar sport and commercial fisheries, and various recreational activities. It also provides habitat for migratory waterfowl, wading birds, alligators (*Alligator mississippiensis*), and the Everglade snail kite (*Rostrhamus sociabilis plumbeus*) (Aumen, 1995). The lake is also used for flood control during the wet season (June–October) and water supply during the dry season (November–May). The lake faces three major environmental challenges: (1) excessive TP loads, (2) extreme water level fluctuations, and (3) the rapid spread of exotic and nuisance plants.

Lake Okeechobee receives water from a 3.45-million ac (1.4-million ha) watershed that includes four distinct tributary systems: Kissimmee River Valley, Lake Istokpoga–Indian Prairie/Harney Pond, Fisheating Creek, and Taylor Creek/Nubbin Slough (**Figure 8-1**). With the exception of Fisheating Creek, all major inflows to Lake Okeechobee are controlled by gravity-fed or pump-driven water control structures. These four major tributary systems are generally bound by the drainage divides of the major water bodies and are further divisible into 61 drainage basins and grouped by nine sub-watersheds based on hydrology and geography.

The nine sub-watersheds comprising the Lake Okeechobee Watershed (LOW) are the Upper Kissimmee (above structure S-65), Lower Kissimmee (between structures S-65E and S-65), Taylor Creek/Nubbin Slough (S-191, S-133, S-135, S-154, and S-154C basins), Lake Istokpoga (above structure S-68), Indian Prairie (C-40, C-41AN, C-41AS, C-41N, C41S, L-48, L-49, L-59E, L-59W, L-60E, L-60W, L-61E, and S-131 basins), Fisheating Creek (Fisheating Creek, L-61W, and Nicodemus Slough North basins), East Lake Okeechobee (Basin 8, C-44, S-153, and L-8 basins), West Lake Okeechobee (East Caloosahatchee, Hicpochee North, and Nicodemus Slough South), and South Lake Okeechobee, which includes the S-4 Basin, and most basins in the Everglades Agricultural Area (EAA), as well as Chapter 298, F.S. Districts (**Figure 8-1**).

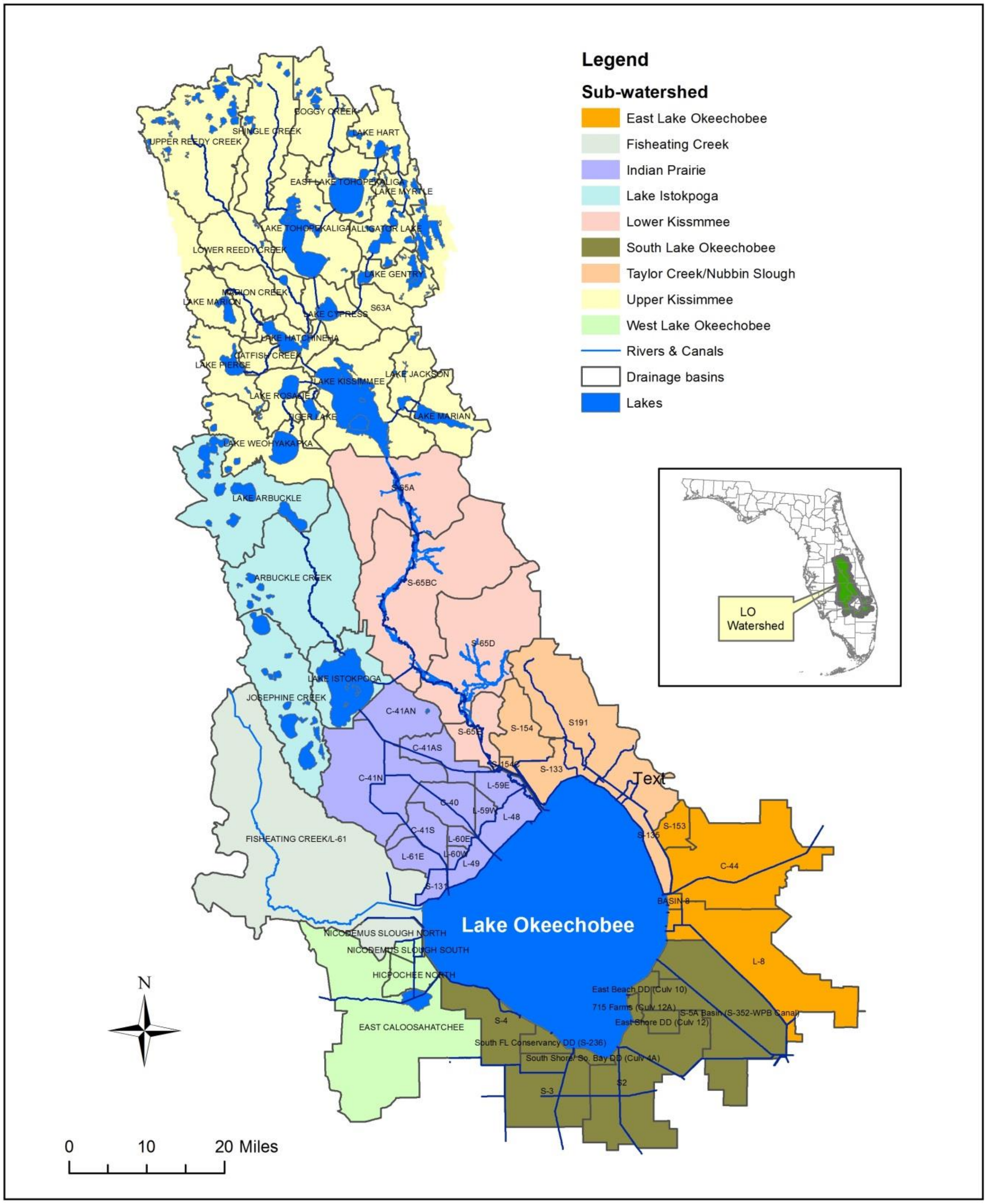


Figure 8-1. Lake Okeechobee Watershed (LOW) detailing sub-watersheds, drainage basins, and major hydrology.

The Upper Kissimmee, Lower Kissimmee, Taylor Creek/Nubbin Slough, Lake Istokpoga, Indian Prairie, and Fisheating Creek sub-watersheds primarily drain into Lake Okeechobee by gravity. The S-133 Basin (part of the Taylor Creek/Nubbin Slough Sub-watershed) and other urban areas can also pump water into the lake from the north. When high lake stages make gravity flows impossible, urban areas north of the lake are drained via pumps. The Eastern and Western Lake Okeechobee sub-watersheds contribute flow by gravity, but only when Lake Okeechobee water levels are below 14.5 and 11.5 ft (4.4 and 3.5 m), respectively, in relation to the National Geodetic Vertical Datum of 1929 (NGVD).

Land uses shown in **Figure 8-2** are part of a 2009 land use dataset which was developed in January 2013 as part of the Nutrient Budget Tool (PN-Budget) Upgrade and Calibration Project (JGH Engineering, 2013). As some of the Lake Okeechobee Watershed area lies within the St. Johns River and Southwest Florida Water Management Districts (SJRWMD and SWFWMD, respectively), the land use dataset was created by merging the SWFWMD 2009, SJRWMD 2009, and SFWMD 2008/9 land use datasets and then clipping these to the study area.

The agricultural land use accounts for 51 percent of the Lake Okeechobee Watershed total area[1.75 million ac, or 706,000 hectares (ha)]; followed by natural areas including wetlands, upland forests, and water bodies (31 percent). Urban areas comprise approximately 10 percent of the land use. The majority of agricultural land uses are improved pasture (20 percent), followed by unimproved/woodland pasture (9 percent) for beef cattle grazing north of the lake. Sugarcane production is primarily south of the lake within the EAA and citrus groves are located primarily within the East Lake Okeechobee and Lake Istokpoga sub-watersheds. Sod farms, row crops, dairies, and other agriculture make up the remaining land uses within the watershed. Further information on detailed land use breakdown is presented in the 2014 Lake Okeechobee Watershed Protection Plan (LOWPP) Update (Bertolotti et al., 2014).

For the East Lake Okeechobee Sub-watershed, the major land use is agriculture, followed by wetland, upland forest and urban land uses. The Fisheating Creek and the West Lake Okeechobee sub-watersheds are dominated by agricultural land uses, followed by wetland and upland forest. The Indian Prairie and Lower Kissimmee Sub-watersheds are dominated by agricultural land uses, followed by wetland and rangeland. For Lake Istokpoga and Upper Kissimmee Sub-watershed, the major land use is agriculture, followed by wetland and urban land uses. The South Lake Okeechobee Sub-watershed and Taylor Creek/Nubbin Slough Sub-watersheds are dominated by agricultural land uses, followed by urban, wetland, and water.

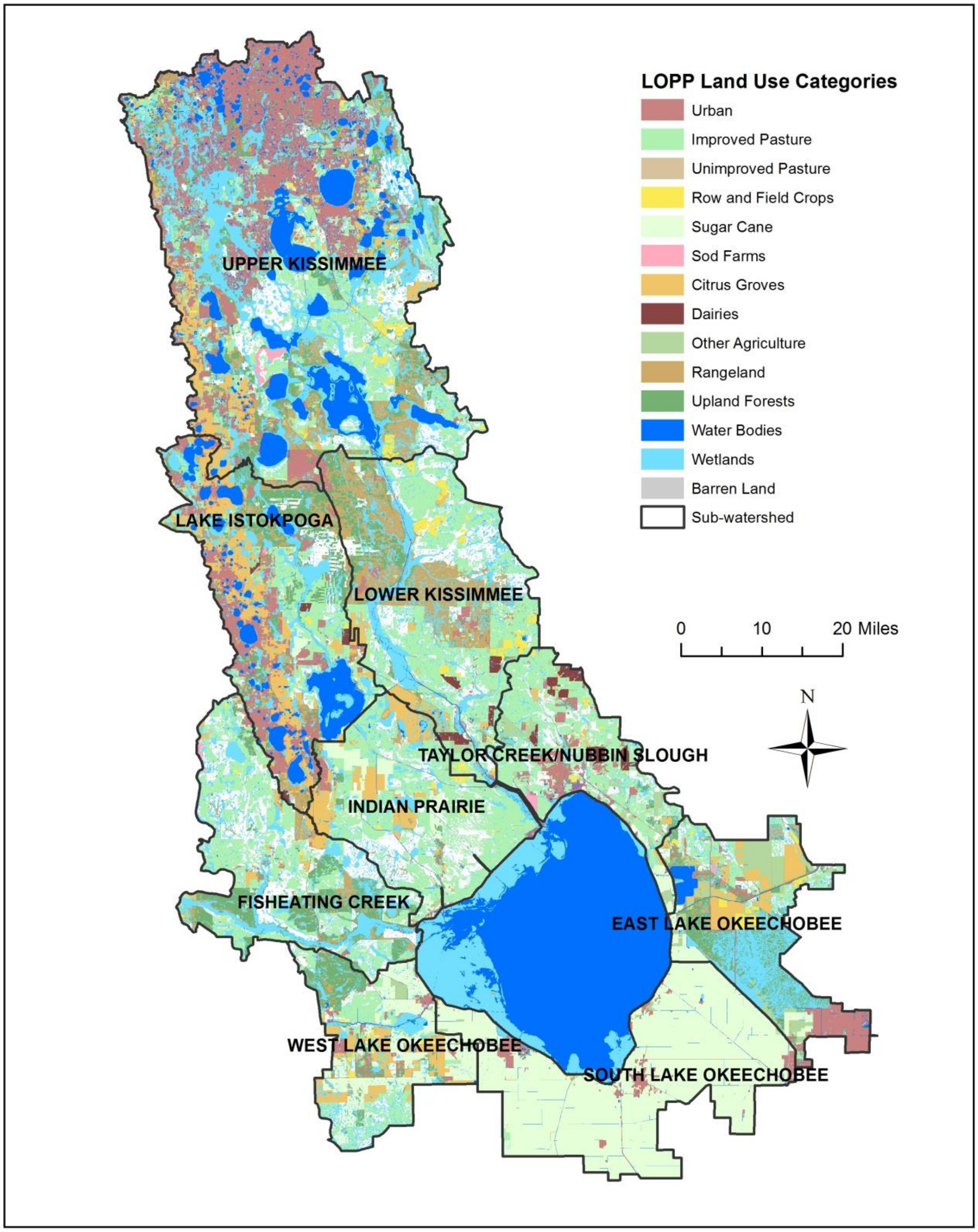


Figure 8-2. Land use distribution detailing Florida FLUCCS level III for agriculture and level I for other land uses in the LOW.

OVERVIEW OF THE LAKE OKEECHOBEE WATERSHED PROTECTION PROGRAM

Passed in 2000, the Lake Okeechobee Protection Act (LOPA) [Section 373.4595, Florida Statutes (F.S.)] established a restoration and protection program for the lake. In 2007, the Florida legislature amended the LOPA which is now known as the Northern Everglades and Estuaries Protection Program (NEEPP). The NEEPP promotes a comprehensive, interconnected watershed approach to protect Lake Okeechobee and the Caloosahatchee and St. Lucie rivers and estuaries (SFWMD et al., 2008). The NEEPP includes the Lake Okeechobee, Caloosahatchee River, and St. Lucie River watershed protection programs. The protection plans developed pursuant to NEEPP for each of these three Northern Everglades watersheds identify actions (e.g. programs and projects) to help in achieving water quality and quantity objectives for the watersheds and to restore habitat. Water quality objectives are based on Total Maximum Daily Loads (TMDLs) established by the Florida Department of Environmental Protection (FDEP). The TMDL for Lake Okeechobee is 140 metric tons (mt) of total phosphorus (TP) per year, which consists of 105 mt of TP per year from the watershed tributaries and 35 mt per year from atmospheric deposition. Storage targets are aimed at achieving appropriate water levels in Lake Okeechobee and more desirable salinities within the estuaries.

The District, in cooperation with the FDEP and Florida Department of Agriculture and Consumer Services (FDACS), collectively known as the coordinating agencies, developed the Lake Okeechobee Protection Plan, which is reevaluated every three years pursuant to the NEEPP. The Lake Okeechobee Protection Plan was originally submitted to the Florida legislature on January 1, 2004 (SFWMD et al., 2004), the Lake Okeechobee Phase II Technical Plan (LOP2TP) was submitted to the Florida legislature in February 2008 (SFWMD et al., 2008), and three-year evaluations to the LOWPP were completed in 2011 and 2014 as required by the NEEPP (SFWMD et al., 2011 and 2014).

The coordinating agencies are jointly responsible for implementing the NEEPP, each with specific areas of responsibility. The FDEP's Basin Management Action Plans (BMAPs) in the Northern Everglades serve as the overarching water quality restoration plans. Other major responsibilities of the coordinating agencies include implementation of urban and agricultural source control programs, identification and implementation of water quality and quantity projects, and reporting and maintaining a monitoring network. The SFWMD, in cooperation with the FDEP and FDACS, is the lead agency for annual status reports and three-year updates to the LOWPP; however, each agency is responsible for implementing its respective programs.

The NEEPP requires the District to submit an annual progress report to the Florida legislature. This chapter fulfills the annual progress report requirement of NEEPP for the Lake Okeechobee Watershed and constitutes the fourteenth annual progress report summarizing the hydrology, water quality, and aquatic habitat conditions of the lake and its watershed based on the results of research and water quality monitoring, as well as the status of the Lake Okeechobee Watershed Construction Project (LOWCP). The annual progress reports and three year updates for the St. Lucie and Caloosahatchee river watersheds are provided in Chapter 10 of this Volume. More details on exotics within the District boundaries and certain source control programs for surrounding watersheds are presented in Chapters 7 and 4 of this volume, respectively. In addition, Northern Everglades Fiscal Year 2014 (FY2014) (October 1, 2013–September 30, 2014) expenditures and the Northern Everglades Annual Work Plan for FY2015 are included in Appendix 1-6 of this volume.

The LOWPP is a major component of the NEEP and includes three main components: (1) the Lake Okeechobee Watershed Phosphorus Control Program; (2) the Lake Okeechobee Watershed Construction Project, which includes the Phase I and Phase II Technical Plans); and (3) the Lake Okeechobee Watershed Research and Water Quality Monitoring Program (**Figure 8-3**). A brief description of these elements is provided below. In addition, the LOWPP includes the Lake Okeechobee Exotic Species Control Program and Lake Okeechobee Internal Phosphorus Management Program. Further information on these programs is presented in the 2014 LOWPP Update (Bertolotti et al., 2014).

The Lake Okeechobee Watershed Phosphorus Control Program is a multifaceted program that includes (1) continued implementation of regulatory and incentive based agricultural and nonagricultural BMPs, (2) development and implementation of improved BMPs, (3) improvement and restoration of hydrologic function of natural and managed systems, and (4) use of alternative technologies for nutrient reduction. The District, FDEP, and FDACS cooperatively implement this program through an interagency agreement in coordination with existing regulatory programs, including the Lake Okeechobee Works of the District Permitting Program [Chapter 40E-61 Florida Administrative Code (F.A.C.)], FDEP Dairy Rule (Chapter 62-670.500, F.A.C.), and Everglades Forever Act [Section 373.4592, F.S.].

According to the NEEPP, the multifaceted approach to reducing P loads by improving the management of P sources within the watershed includes implementation of existing regulations and BMPs and development and implementation of improved BMPs. The District continues to implement the delegated Environmental Resource Permitting (ERP) program and mandated Lake Okeechobee Works of the District (WOD) nutrient source control program, which are described in Chapter 4 of this volume. The District also collects water quality monitoring data at sites identified as key locations for tracking progress toward achieving water quality goals and identifying water quality concerns and potential areas for BMP improvement. The NEEPP requires FDACS to implement an incentive-based BMP program on agricultural lands within the Lake Okeechobee Watershed. The FDEP implements the ERP program and other urban BMP programs and rules. More details about the Lake Okeechobee Watershed Phosphorus Control Program are provided in the 2014 LOWPP Update (Bertolotti et al., 2014). District source control activities for Water Year 2014 (WY2014) (May 1, 2013– April 30, 2014) and anticipated WY2015 activities are presented in Chapter 4 of this volume.

The LOWCP identifies a suite of best available water quality and storage projects to improve hydrology, water quality, and aquatic habitats within the watershed. For a detailed description of the LOWCP and the associated activities see the 2014 LOWPP Update (Bertolotti et al., 2014). Updates on the LOWCP activities are provided under the *Watershed Construction Project Update* section of this chapter.

The District in cooperation with the other coordinating agencies developed a research and water quality monitoring program, as required by NEEPP. The plan includes a flow, water quality, and ecological monitoring network. The data from this network is used to assess progress toward achieving goals and to monitor the ecological health of the system. It also includes projects aimed toward improving our understanding of the system. Results from the monitoring and updates on research and water quality monitoring program are provided in this chapter.

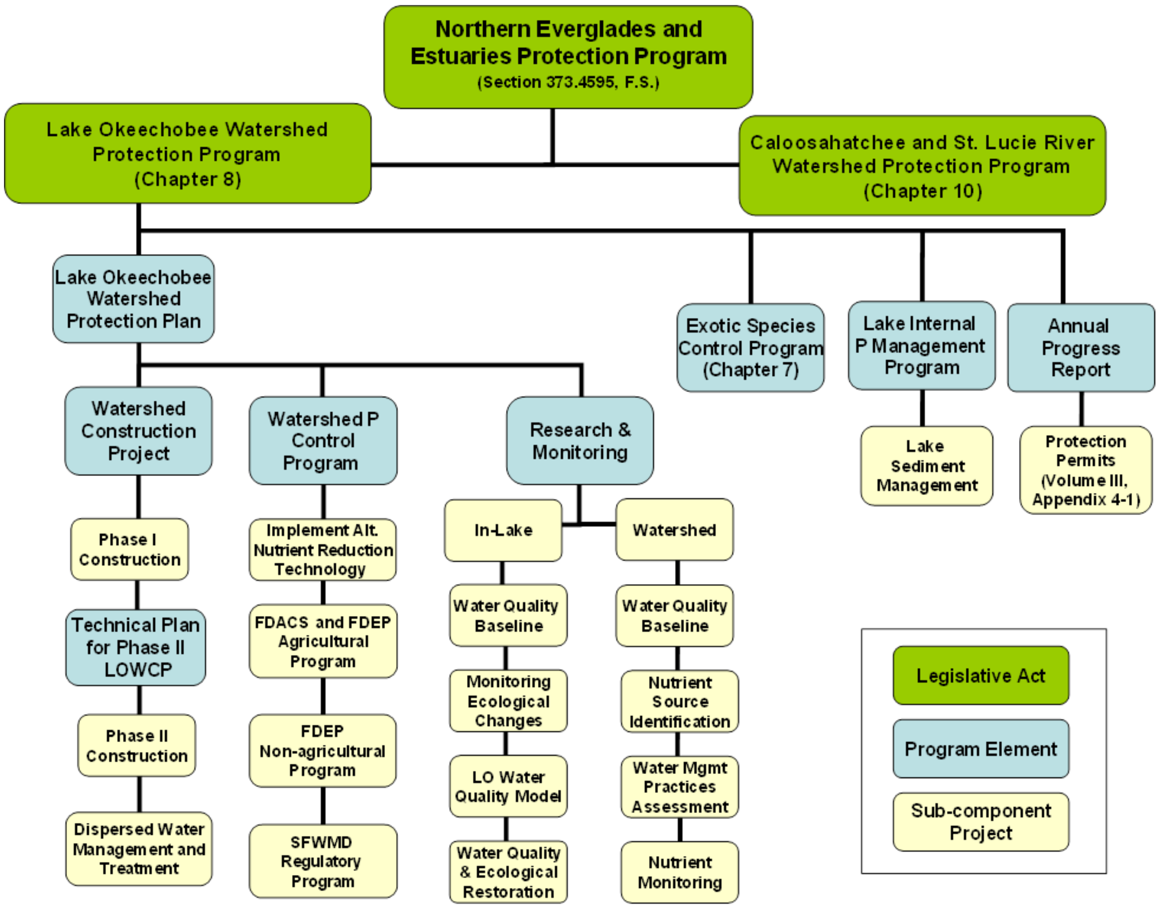


Figure 8-3. Northern Everglades and Estuaries Protection Program (NEEPP) structure, detailing the Lake Okeechobee Watershed Protection Program's (LOWPP) elements and projects. [Note: F.S. – Florida Statutes; LOWCP – Lake Okeechobee Watershed Construction Project; P – phosphorus; Alt. – Alternate; FDACS – Florida Department of Agricultural and Consumer Services; FDEP – Florida Department of Environmental Protection; SFWMD – South Florida Water Management District; and LO – Lake Okeechobee.]

WATERSHED CONSTRUCTION PROJECT UPDATE AND RELATED ACTIVITIES

This section provides updates to the LOWCP and related activities during WY2014. Project background information and details are documented in the 2011 LOWPP Update (SFWMD et al., 2011), available at www.sfwmd.gov/northerneverglades. Addressing the complex and varying problems in the Lake Okeechobee Watershed requires a multifaceted restoration approach. The coordinating agencies are committed to restoring Lake Okeechobee and its watershed, continuing existing efforts, and identifying new opportunities to improve the ecosystem. Over the past three years, the coordinating agencies have implemented various efforts to improve conditions including: initial operation of Lakeside Ranch Stormwater Treatment Area (STA) Phase I, continued operation of a pilot-scale STAs in Taylor Creek expansion of the Dispersed Water Management Program, continued effort on the Kissimmee River Restoration Project, and implementation of Hybrid Wetland Treatment Technology and Floating Aquatic Vegetative Tilling technologies to remove nutrients at sub-basin and farm scales (**Table 8-1**). The SFWMD is continuing to coordinate with the USACE on the Kissimmee River Restoration Project and more details on this coordination effort can be found in Chapter 9. The status of the C-44 Reservoir/STA Project is reported in the *St. Lucie Estuary Watershed Construction Project Update* section in Chapter 10 of this volume.

A key component to achieving water quality goals in the Northern Everglades are FDEP's Basin Management Action Plans (BMAPs), which serve as the overarching water quality restoration plans. A BMAP is the "blueprint" for restoring impaired waters by reducing pollutant loadings to meet a Total Maximum Daily Load (TMDL). It represents a comprehensive set of strategies — permit limits on wastewater facilities, urban and agricultural BMPs, conservation programs, financial assistance and revenue generating activities, etc. — designed to implement the phosphorus load reductions established by the TMDL. In early 2013, the FDEP initiated development of the Lake Okeechobee BMAP. The Lake Okeechobee BMAP will build upon the decade plus work already completed under the LOWPP. Developed collaboratively with existing and new stakeholders, it will work in combination with the regulatory programs and provide for an enforceable framework necessary to achieve restoration. These actions, coupled with the LOWPP, make for a comprehensive suite of actions to address Lake Okeechobee restoration. The Lake Okeechobee BMAP development continued through 2014 with multiple stakeholder meetings. The first Lake Okeechobee BMAP document, focused on the six sub-watersheds north of the lake, was completed and adopted in December 2014.

The FDEP will work with stakeholders and coordinating agencies through BMAP implementation to track progress toward achieving goals, identify the projects necessary to achieve the TMDLs, and estimate project nutrient reduction benefits. Future LOWPP updates will incorporate this information as appropriate.

Table 8-1. General description and status of Lake Okeechobee Watershed Construction projects during WY2014.

Project Name (Investigator)	Sub-Watershed	General Description	Size/Capacity	Estimated Water Quality and Quantity Benefits	Year Construction Started and Completed (or Expected Completion Date)	WY2014 Status Update
Lakeside Ranch Stormwater Treatment Area (LR-STA) (SFWMD)	Taylor Creek/ Nubbin Slough	This project, expedited under the NEEPP, involves a 2,700 ac (1,090 ha) site in western Martin County on lands adjacent to Lake Okeechobee. The project is designed in two phases: The Phase I northern STA and inflow pump station; and the Phase II southern STA, including a second pump station to manage rim canal levels in Lake Okeechobee during high water flow periods and recirculate Lake Okeechobee water through the STA for additional phosphorus removal.	The northern STA has an effective treatment area of 919 ac (372 ha) and the pump's capacity is at 250 cfs or 7 m^3/sec. The southern STA has an effective treatment area of 788 ac (319 ha).	The design document estimated an average annual load reduction of 19 mt/yr with 9 mt/yr from Phase I and 10 mt/yr from Phase II.	Northern STA started in 2009 and S-650 pump station started in 2010. Both were completed in 2012. Phase II construction is contingent on funding.	From July 3, 2013 to April 30, 2014, LR-STA Cell 1 treated 3,096 ac-ft (3,817,368 m^3) of runoff while discharging 1,992 ac-ft (2,456,136 m^3) back into L-47 canal. It retained 1.17 mt of TP out of 1.22 mt it received for a treatment efficiency of 95.5 percent. LR-STA Cell 2 performed better than Cell 1, removing practically all of the TP mass it received. A total of 3.06 mt of TP were loaded into Cell 2 while only 0.05 mt were discharged back into L-47 canal, giving a phosphorus removal efficiency of over 98 percent. The two cells combined removed 4.18 mt of TP from the surface water within STA during the 10-month period in WY2014.

Table 8-1. Continued.

Project Name (Investigator)	Sub-Watershed	General Description	Size/Capacity	Estimated Water Quality and Quantity Benefits	Year Construction Started and Completed (or Expected Completion Date)	WY2014 Status Update
Taylor Creek Stormwater Treatment Area (TC-STA) (SFWMD)	Taylor Creek/ Nubbin Slough	This project is located on District owned lands at the Grassy Island Ranch along the banks of Taylor Creek. This project is part of the Lake Okeechobee Critical Restoration Project which was authorized through the federal Water Resources Development Act of 1996. The United States Army Corps of Engineers (the Corps) was responsible for the design and construction of the STA and the South Florida Water Management District (SFWMD) is responsible for operations and maintenance.	The site is 142 ac (57 ha) with an effective treatment area of 118 acres (48 ha) This two-celled STA in series is expected to treat about 10 percent of the water flow in Taylor Creek.	Based on measured data from 2008 to 2013, approximately 1 mt TP load reduction was obtained on annual average basis.	Started in 2006 and completed in 2008	During the first quarter of WY2014, the STA was in the midst of a drawdown as part of a continuing effort to enhance vegetative conditions. The resumption of flow-through operation was started on July 30, 2013 and had uninterrupted operation for the next nine months until April 30, 2014. During this period, the STA received 1.62 mt of TP and retained 0.63 mt for a treatment efficiency of 39 percent. The natural recruitment of cattail and plantings conducted during drawdown increased the emergent vegetation coverage to 95 and 75 percent in Cell 1 and Cell 2, respectively. The recent plantings conducted in Cell 2 from May-June 2014 increased the vegetation coverage to 95 percent in that cell.
Nubbin Slough Stormwater Treatment Area (NS-STA) (SFWMD)	Taylor Creek/ Nubbin Slough	This STA is located on District owned lands at the New Palm Dairy site along the banks of Nubbin Slough. This project is part of the Lake Okeechobee Critical Restoration Project, which was authorized through the federal Water Resources Development Act of 1996. The Corps was responsible for the design and construction of the STA and the SFWMD is responsible for operations and maintenance.	This two-celled STA is 809 ac (327 ha) with an effective treatment area of 773 ac (313 ha).	The projected long-term average TP reduction within the STA is approximately 5 mt/yr (Stanley Consultants, Inc., 2003)	Started in 2005 and completed in 2006	Completing repairs, commissioning the pump station, and transferring the facility to the SFWMD is anticipated to occur in WY15.

Table 8-1. Continued.

Project Name (Investigator)	Sub-Watershed	General Description	Size/Capacity	Estimated Water Quality and Quantity Benefits	Year Construction Started and Completed (or Expected Completion Date)	WY2014 Status Update
Dispersed Water Management (DWM) Program (SFWMD)	All Lake Okeechobee sub-watersheds except the South Lake Okeechobee Sub-watershed	The goals and objectives of the DWM Program are to provide shallow water storage to enhance Lake Okeechobee and estuary health by reducing discharge volumes, reducing nutrient loading to downstream receiving waters, and expanding ground water recharge opportunities. The four main categories of projects under the DWM Program include storage and retention projects on private lands, storage and retention projects on public lands, Northern Everglades Payment for Environmental Services (NE-PES) projects on ranchlands, and Water Farming Payment for Environmental Services (WF-PES) pilot projects on fallow citrus lands. More details on the DWM Program and specific projects can be found in Chapter 10 of this volume.	See Table 10-4 of this volume for project specific details.	The storage, retention, and detention created by projects within the DWM Program since 2005 will be approximately 93,202 ac-ft. This includes contributions from other agencies and landowners.	The program started in 2005 and is ongoing.	During WY 2014 a 2nd Request for Proposals for Northern Everglades Payment for Environmental Services (NE-PES 2) projects was completed and two contracts were executed. Additional funding was appropriated by the State Legislature allowing for negotiations with the subsequent ranked respondents. The Nicodemus Slough DWM project was completed in the summer of 2014. This is a substantial project with storage estimates of 33,860 ac-ft per year. For additional information on the DWM program, please see Chapter 10 of this Volume which houses the 2014 River Watershed Protection Updates.

Table 8-1. Continued.

Project Name (Investigator)	Sub-Watershed	General Description	Size/Capacity	Estimated Water Quality and Quantity Benefits	Year Construction Started and Completed (or Expected Completion Date)	WY2014 Status Update
Kissimmee River Restoration Project (KRRP) (SFWMD)	Lower Kissimmee	The main goal of KRRP is to restore ecological integrity to approximately one-third of the river and its floodplain that existed before the river was channelized in the 1960s. Achieving these conditions involves acquiring more than 102,000 ac (41,280 ha) of land in the river's floodplain and headwaters, backfilling 22 miles (35 km) of the C-38 canal, reconnecting remnant sections of the original river channel, removing two water control structures, modifying portions of the river's headwaters, and implementation of the Headwaters Regulation Schedule (HRS) to meet the project hydrologic criteria needed to meet KRRP ecological goals. More detail on KRRP is available in Chapter 9 of this volume.	The first three construction phases of restoration have reestablished flow to 24 miles (39 km) of river channel and allowed intermittent inundation of 15,041 ac (6,089 ha) of floodplain.	The 2008 Phase II Technical Plan (SFWMD et al., 2008) provided TP load reduction estimate of 20.6 mt/yr.	The first three construction phases of restoration were completed between 2001 and 2009. The last major phases of construction are scheduled to begin in 2015 and are currently scheduled for completion in 2017.	Contract 18A - S-65EX1 is under construction and Contract 15A - River Acres Supplemental Work will be awarded before the end of FY14. Real estate acquisition is nearly complete in the lower Kissimmee basins and the next major backfill contracts are expected to be awarded in FY15.
Everglades Headwaters National Wildlife Refuge and Conservation Area (USFWS)	North of the Lake	This multi-partnered effort promotes habitat conservation through land acquisition, permanent conservation easements, and agreements with willing landowners. The refuge and conservation area was authorized to protect 150,000 ac (60,700 ha) in the threatened grassland, long-leaf pine savanna, sandhill, and scrub landscapes north of Lake Okeechobee, through fee title acquisition and permanent conservation easements on private lands allowing continued cattle and agricultural production while preventing future commercial, industrial, and residential development. The main entities in the effort include the FWC, USDA NRCS, U.S. Department of Defense, The Nature Conservancy, and National Wildlife Refuge Association.	Two-thirds of the 150,000 ac (60,700 ha) refuge and conservation acreage, or 100,000 ac (4,047 ha), will be protected through conservation easements purchased from willing sellers.	This project will provide regional environmental and economic benefits through conserving ecologically significant lands and natural resources.	The initial planning for this project began with a proposal developed by the USFWS in August 2010. The USFWS concluded their planning efforts and formally established the Everglades Headwaters National Wildlife Refuge and Conservation Area on January 18, 2012.	

Table 8-1. Continued.

Project Name (Investigator)	Sub-Watershed	General Description	Size/Capacity	Estimated Water Quality and Quantity Benefits	Year Construction Started and Completed (or Expected Completion Date)	WY2014 Status Update
Fisheating Creek Special Wetland Reserve Program Project (NRCS)	Fisheating Creek	The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) under the Wetlands Reserve Program (WRP) partners with landowners providing assistance to the landowners for the restoration and protection of wetlands through 30-year term or permanent easements and cost-share restoration agreements. The FEC easement consists of five easements of land that cover approximately 34,122 ac (13,810 ha) encompassing a significant portion of the Fisheating Creek headwaters in Highlands County. Once the land is restored, it will enhance and improve wetlands, wildlife habitat and the quality of the water draining into the Everglades.	N/A	This project will restore and enhance wetland ecosystems, recharge groundwater, reduce flooding, and improve fish and wildlife habitat including threatened and endangered species	The initial planning for this project began in 2010 with design anticipated to commence in 2015 followed by construction in early 2016.	The NRCS completed a draft environmental assessment report that was circulated for comments in WY 2014. Alternatives being considered in the EA will increase the existing wetlands in the project footprint up to 9,203 ac (3,724 ha).

Table 8-1. Continued.

Project Name (Investigator)	Sub-Watershed	General Description	Size/Capacity	Estimated Water Quality and Quantity Benefits	Year Construction Started and Completed (or Expected Completion Date)	WY2014 Status Update
Hybrid Wetland Treatment Technology (HWTT) (FDACS)	Taylor Creek and Nubbin Slough Sub-Watershed and St. Lucie River Watershed.	The HWTT technology combines attributes of treatment wetlands and chemical treatment systems. There are currently six operational HWTT systems and one under permitting in the Northern Everglades; five in the Lake Okeechobee Watershed (Nubbin Slough, Mosquito Creek, Lemkin Creek, Grassy Island and Wolff Ditch) and two in the St. Lucie River Watershed (Ideal 2 Grove and Bessey Creek).	Ideal 2 Grove, 1.3 cfs (0.04 m^3/sec); Nubbin Slough, 7.4 cfs (0.21 m^3/sec); Mosquito Creek, 6 cfs (0.17 m^3/sec); Lemkin Creek, 5 cfs (0.14 m^3/sec); Wolff Ditch, 20 cfs (0.57 m^3/sec); and Grassy Island in the Taylor Creek basin, 30 cfs (0.85 m^3/sec).	Flow-weighted mean TP concentration reductions of the six active HWTT facilities during the entire study period ranged from 67 to 93 percent. The design capacity for Bessey Creek is 20 cfs (0.57 m^3/sec).	Ideal 2 Grove, Nubbin Slough, and Mosquito Creek were constructed in WY2008; Lemkin Creek and Wolff Ditch were deployed in WY2011; and Grassy Island was constructed in WY2012 with final expansion in WY2014.	The Grassy Island expansion to 30 cfs (0.85 m^3/sec) was completed in WY2014. Application was submitted to FDEP to operate at Grassy Island at 30 cfs (0.85 m^3/sec). A new facility at Bessey Creek in Martin County is under final design and permitting and is expected to be completed and operational in the fall of 2014.
Floating Aquatic Vegetative Tilling (FAVT) (FDACS)	Fisheating Creek and West Lake Okeechobee	Floating Aquatic Vegetative Tilling (FAVT) systems are operated with an initial growing season during which the FAV assimilate nutrients and grow densely. The FAVT is then drained during the dry season, thereby stranding the FAV on the soil. After a natural drying process, the plant material is tilled into the soil, stored in deeper zones, and used to repopulate the wetland for the subsequent growth period. The technology uses the direct assimilation of nutrients from the water column through the use of floating plant roots (as compared to plants rooted in the soil), and all of the biomass is rapidly incorporated directly into the soil through tilling. The FAVT process may result in a reduction of up to 80 percent of land needed for treatment as compared to traditional wetland treatment systems.	The East Caloosahatchee FAVT site is 540 acres (219 ha) and has a capacity of 90 cfs (2.55 m^3/sec). It is designed to treat local agricultural runoff from the Hendry Hilliard Water Control District, the East Caloosahatchee River and Lake Okeechobee. The Fisheating Creek facility is comprised of 100 acres (40 ha) of FAV and 200 acres (81 ha) of managed dispersed flow area and will have a treatment capacity of 120 cfs (3.4 m^3/sec).	16.2 mt from the Fisheating Creek FAVT. The East Caloosahatchee FAVT facility is anticipated to remove approximately 6 mt of TP.	The East Caloosahatchee facility was completed in June 2014. The Fisheating Creek facility has an expected completion date in 2015.	The East Caloosahatchee FAVT project is operational. Legislative funding has been appropriated for a FAVT site to treat water from the Fisheating Creek Sub-watershed.

WATERSHED ASSESSMENT, MONITORING AND RESEARCH

WATER QUALITY MONITORING

As required by NEEPP, the District monitors the water quality of inflows to and outflows from Lake Okeechobee at District-operated control structures and maintains a long-term water quality monitoring network within the Lake Okeechobee Watershed (**Figure 8-4**). This network is continuously reviewed for efficiency and to ensure all data objectives associated with legislatively mandated and permit required monitoring are being met. This informs stakeholders and the public on the progress of federally and state-funded restoration efforts. In addition, the District coordinates monitoring efforts with the FDACS, FDEP, and United States Geological Survey (USGS) to leverage monitoring sites and reduce duplication of efforts.

The District's current monitoring network includes sample locations at three hydrologic levels within the Lake Okeechobee Watershed: (1) sub-watershed and drainage basin level (basin loading stations), (2) sub-basin level (tributary and ambient stations), and (3) project/parcel/farm level (dairy stations). Load monitoring is conducted at stations at the sub-watershed and drainage basin level (basin loading stations). Drainage basin loading stations are monitored for TP, TN, and flow. The FDEP issued Lake Okeechobee Operating Permit issued requires additional Class I water quality parameters be collected from 34 control structures with direct discharges into Lake Okeechobee. The sub-basin level concentration monitoring is conducted at ambient monitoring stations and tributary stations under three different projects: the ambient long-term trend projects, which are the Kissimmee River Eutrophication Abatement (KREA) and Taylor Creek Nubbins Slough (TCNS) projects and sites formerly part of the sub-basin loading project (OKUSGS). The District collects and analyzes water quality from the OKUSGS sites. The USGS, under contract from FDACS, maintains flow data from several of these sites. The Lake Okeechobee Watershed Assessment (LOWA) Project also monitors TP at the tributary level and is used to support the Works of the District BMP Program, Chapter 40E-61, F.A.C. (see Chapter 4 of this volume). The collection of data from project-specific, parcel- or farm-level monitoring (dairy monitoring stations) is the third tier of monitoring conducted under the umbrella of the watershed network. Data from all these monitoring efforts reside in the District's hydrometeorologic database (DBHYDRO) and are associated with the project names listed above in parentheses.

Total Phosphorus and Total Nitrogen Loads to Lake Okeechobee

TP loading rates into Lake Okeechobee varied over time as a result of a combination of climatic conditions, land use changes, and changes in water management conditions. Extreme climatic conditions were experienced in WY2014. The rainfall estimates for the Lake Okeechobee Basin and District-wide were 2.6 and 1.1 inches above the 30-year average. For the Okeechobee region, the first three months of the water year exceeded the average rainfall by 7.3 inches. Drier to near normal conditions occurred in the succeeding months. For more information on rainfall in WY2014, see Chapter 2 of this volume and Volume III, Appendix 4-1.

As shown in **Table 8-2**, TP loads to the lake from tributaries and atmospheric deposition (estimated as 35 mt per year) totaled 609 mt in WY2014. This was 7 percent (40 mt) more than the previous water year and is attributable to the 31 percent higher flow; primarily from the northern basins. From WY1981–WY2014, the highest TP loading rate was 1,189 mt in WY1983, followed by 960 mt in WY2005, and 913 mt in WY1998.

The highest five-year average load was 714 mt during the WY2002–WY2006 period of record (mainly due to the high discharges to the lake during and after the 2004 and 2005 hurricanes). The five-year average from WY2007–WY2011 was the lowest average value since

1981 because it included three of the driest years (WY2007, WY2008, and WY2011) on record. The most recent five-year average load was 442 mt (WY2010–WY2014), which exceed the TMDL by 302 mt. This five-year average includes one regional drought that lasted from December 2010 to October 2011. During this period, flow and load to the lake were reduced substantially compared to a 1991–2005 baseline of 2.54 million ac-ft and 546 mt TP (James and Zhang, 2008). The overall average flow in the past five years was 2.06 million ac-ft (see Volume III, Appendix 4-1, Tables 15 and 16), which is 0.48 million ac-ft below the baseline. The previous five-year period (WY2009–WY2013) exceeded the TMDL by 311 mt.

Figure 8-4. Locations of Water Year 2014 (WY2014) (May 1, 2013–April 30, 2014) water quality sampling stations under the ambient, tributary, and basin loading projects in the Lake Okeechobee Watershed.

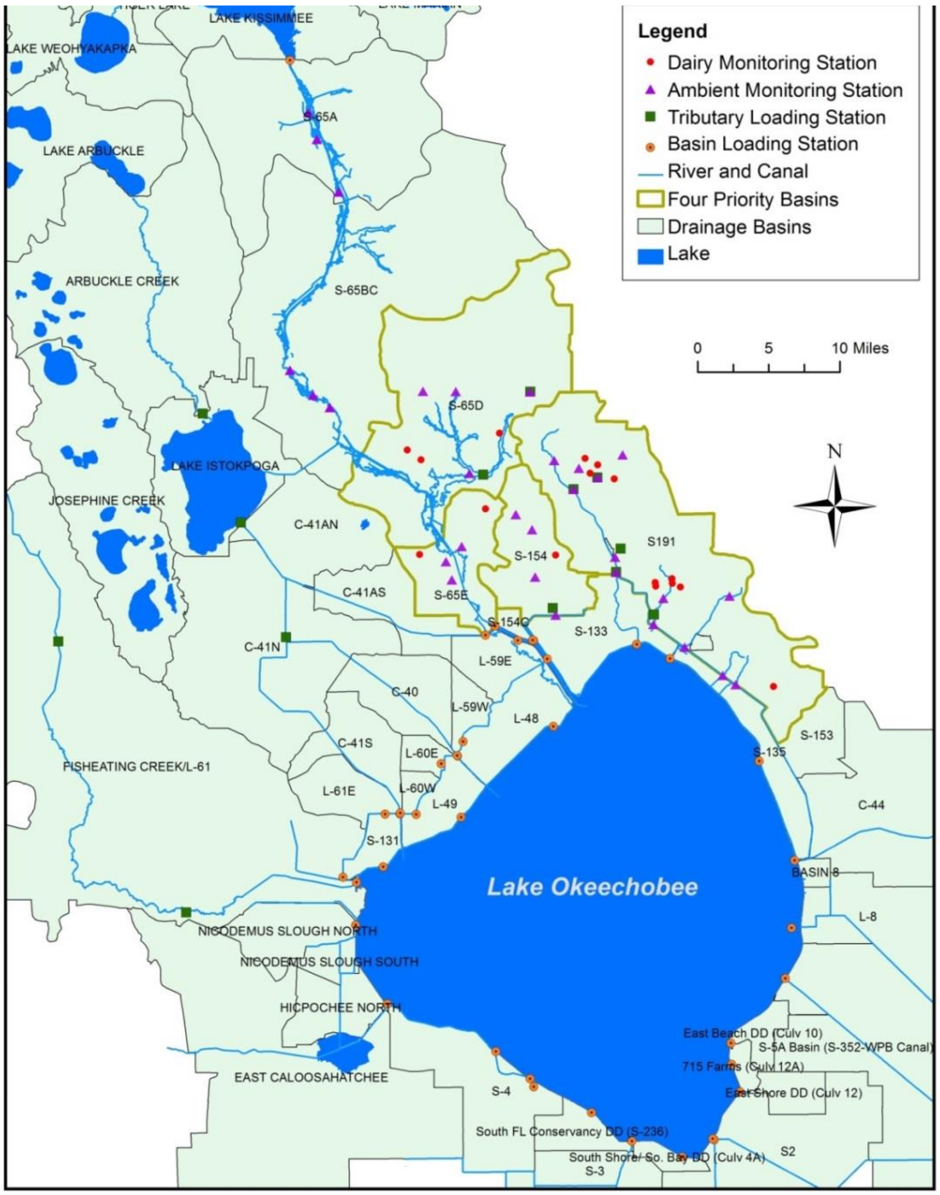


Table 8-2. Annual total phosphorus (TP) loads to Lake Okeechobee in metric tons (mt) from Water Years 1981–2014 (WY1981–WY2014) (May 1, 1980–April 30, 2014). [Note: NA – not available.]

Water Year (May-April)	Measured TP Load[a] (mt)	Long-Term Load (Five-Year Moving Average)[a] (mt)	Long-Term Over-Target Load (Five-Year Moving Average)[a/b] (mt)
1981	151	NA	NA
1982	440	NA	NA
1983	1,189	NA	NA
1984	369	NA	NA
1985	500	530	390
1986	421	584	444
1987	562	608	468
1988	488	468	328
1989	229	440	300
1990	365	413	273
1991	401	409	269
1992	408	378	238
1993	519	385	245
1994	180	375	235
1995	617	425	285
1996	644	474	334
1997	167	425	285
1998	913	504	364
1999	312	531	391
2000	685	544	404
2001	134	442	302
2002	624	533	393
2003	639	479	339
2004	553	527	387
2005	960	582	442
2006	795	715	575
2007	203	630	490
2008	246	551	411
2009	656	572	432
2010	478	496	356
2011	177	352	212
2012	377	387	247
2013	569	451	311
2014	609	442	302

a. Includes an atmospheric load of 35 metric tons per year (mt/yr) based on the Lake Okeechobee Total Maximum Daily Load (TMDL) (FDEP, 2001).

b. Target is the Lake Okeechobee TMDL of 140 mt compared to a five-year moving average.

As shown in **Table 8-3**, from WY2000–WY2014, the highest TN loading rate was 8,775 mt in WY2005, followed by 8,279 mt in WY2003, and 7,992 mt in WY2006. The highest five-year average load was 7,880 mt during the WY2002–WY2006 period of record (mainly due to the high discharges to the lake during and after the 2004 and 2005 hurricanes). The WY2014 TN load was estimated at 6,750 mt, an increase of 353 mt (6 percent) compared to the WY2013 load of 6,397 mt. WY2010–WY2014 TN load averaged 5,401 mt, a 12 mt increase from the WY2009–WY2013 average of 5,389 mt.

Table 8-3. Annual total nitrogen (TN) loads to Lake Okeechobee from WY2000–WY2014 (May 1, 1999–April 30, 2014). [Note: NA – not available.]

Water Year May–April	Measured TN Load[a] (mt)	Long-Term TN Load (Five-Year Moving Average)[a] (mt)
2000	6,693	NA
2001	2,517	NA
2002	7,826	NA
2003	8,279	NA
2004	6,526	6,368
2005	8,775	6,785
2006	7,992	7,880
2007	2,965	6,907
2008	3,393	5,930
2009	6,689	5,963
2010	6,325	5,473
2011	2,913	4,457
2012	4,620	4,788
2013	6,397	5,389
2014	6,750	5,401

a. Includes atmospheric load of 1,233 mt/yr to account for atmospheric deposition

Total Phosphorus and Total Nitrogen Loading Data by Drainage Basin

Surface water flow and TP and TN loads to the lake for WY2014 are calculated for the major drainage basins using the basin loading stations. These calculations include discharges from Lakes Istokpoga and Kissimmee. These lakes are the outfalls of sub-watersheds that collect water flow and nutrient loads from smaller surrounding drainage basins (**Figure 8-4**). Data are based on monitoring stations where flow is continuously monitored and TP and TN samples are collected biweekly, based on flow, or monthly at a minimum. As shown in **Table 8-4**, the TP load to the lake from all drainage basins and atmospheric deposition [estimated at 35 mt (FDEP, 2001)] in WY2014 was 609 mt. The watershed-wide unit area load of TP averaged 0.37 lb/ac (0.41 kg/ha) in WY2014. At the drainage basin level, the highest unit area load of TP in WY2014 come from the L-59W basin (4.15 lb/ac, or 4.65 kg/ha) in the Indian Prairie Sub-watershed, followed by the S-154C basin (2.44 lb/ac, or 2.73 kg/ha), and the Taylor Creek/Nubbin Slough basin (1.41 lb/ac, or 1.58 kg/ha), both in the Taylor Creek/Nubbin Slough Sub-watershed. The flow-weighted TP concentration averaged 165 micrograms per liter (µg/L), or parts per billion (ppb), for the Lake Okeechobee Watershed. The S-154C basin had the highest flow weighted TP concentration value (595 ppb), followed by the Taylor Creek/Nubbin Slough basin (575 ppb) and S-154 basin (518 ppb) during WY2014, and all three of these drainage basins are located in the Taylor Creek/Nubbin Slough Sub-watershed.

Table 8-4. WY2014 surface water inflows (acre-feet, or ac-ft), TP loads (mt) and concentrations [micrograms per liter (μg/L, or parts per billion (ppb)], and unit area load in pounds per acre (lb/ac) from the drainage basins to Lake Okeechobee.

Source	Area		Discharge		TP Load		Unit Area Load	Average TP Conc.
	(acres)	(%)	(ac-ft)	(%)	(mt)	(%)	(lb/ac)	(ppb)
East Lake Okeechobee Sub-watershed	**239,013**	**6.9**	**56,438**	**2.0**	**11.1**	**1.9**	**0.10**	**159**
C-44/S-153/Basin 8 (S-308 at St. Lucie Canal)	132,572	3.8	28,240	1.0	6.2	1.1	0.10	177
L-8 Basin (Culvert 10A)	106,440	3.1	28,198	1.0	4.9	0.9	0.10	142
Fisheating Creek Sub-watershed	**318,042**	**9.2**	**403,020**	**14.3**	**103.1**	**18.0**	**0.71**	**207**
Fisheating Creek at Lakeport/L-61W Basin	298,713	8.7	394,134	13.9	102.6	17.9	0.76	211
Nicodemus Slough North (Culvert 5)	19,329	0.6	8,886	0.3	0.5	0.1	0.05	44
Indian Prairie Sub-watershed	**276,577**	**8.0**	**491,687**	**17.4**	**124.5**	**21.7**	**0.99**	**205**
C-40 Basin [(S-72) – (S-68)]	24,076	0.7	30,419	1.1	13.6	2.4	1.25	363
C-41 Basin [(S-71) – (S-68)]	112,880	3.3	98,510	3.5	48.5	8.5	0.95	399
C-41A Basin [(S-84) – (S-68)]	57,748	1.7	231,572	8.2	33.8	5.9	1.29	118
L-48 Basin (S-127 total)	20,798	0.6	16,781	0.6	3.2	0.6	0.34	155
L-49 Basin (S-129 total)	11,966	0.3	15,708	0.6	1.0	0.2	0.19	54
L-59E Basin [(G-33)+(G-34)]	12,589	0.4	15,546	0.5	3.2	0.6	0.57	169
L-59W Basin (G-74)	6,596	0.2	31,822	1.1	12.4	2.2	4.15	316
L-60E Basin (G-75)	4,944	0.1	6,290	0.2	1.9	0.3	0.85	247
L-60W Basin (G-76)	3,453	0.1	3,336	0.1	0.5	0.1	0.30	116
L-61E Basin	14,407	0.4	30,369	1.1	5.2	0.9	0.80	139
S-131 Basin	7,122	0.2	11,334	0.4	1.1	0.2	0.34	79
Taylor Creek/Nubbin Slough Sub-watershed	**197,795**	**5.7**	**190,904**	**6.8**	**107.6**	**18.7**	**1.20**	**457**
S-133 Basin	25,626	0.7	22,655	0.8	6.4	1.1	0.55	230
S-135 Basin	17,756	0.5	25,847	0.9	2.2	0.4	0.27	69
S-154 Basin	31,815	0.9	30,518	1.1	19.5	3.4	1.35	518
S-154C Basin	2,134	0.1	3,217	0.1	2.4	0.4	2.44	595
Taylor Creek/Nubbin Slough (S-191)	120,464	3.5	108,667	3.8	77.1	13.4	1.41	575
South Lake Okeechobee Sub-watershed	**363,141**	**10.5**	**81,918**	**2.9**	**24.7**	**4.3**	**0.15**	**245**
715 Farms (Culvert 12A)	3,353	0.1	0	-	0.0	0.0	0.00	no flow
East Beach Drainage District (Culvert 10)	6,657	0.2	0	-	0.0	0.0	0.00	no flow
East Shore Drainage District (Culvert 12)	8,409	0.2	0	-	0.0	0.0	0.00	no flow
Industrial Canal	13,024	0.4	18,516	0.7	2.9	0.5	0.49	127
S-2 Basin	106,274	3.1	25,989	0.9	6.4	1.1	0.13	199
S-3 Basin	63,134	1.8	1,396	0.0	0.2	0.0	0.01	88
S-4 Basin	29,121	0.8	36,016	1.3	15.3	2.7	1.16	345
South Florida Conservancy Drainage District (S-236)	9,931	0.3	0	-	0.0	0.0	0.00	no flow
South Shore/South Bay Drainage District (Culvert 4A)	4,036	0.1	0	-	0.0	0.0	0.00	no flow
S-5A Basin (S-352 West Palm Beach Canal)	119,202	3.5	0	-	0.0	0.0	0.00	no flow
West Lake Okeechobee Sub-watershed (S-77)	**204,094**	**5.9**	**543**	**0.0**	**0.1**	**0.0**	**0.00**	95
East Caloosahatchee Basin (S-77)	198,178	5.7	0	-	0.0	0.0	0.00	no flow
Nicodemus Slough South (Culvert 5A)	5,916	0.2	543	0.0	0.1	0.0	0.02	95
Lake Istokpoga Sub-watershed (S-68)	**394,203**	**11.4**	**319,313**	**11.3**	**30.2**	**5.3**	**0.17**	**77**
Lower Kissimmee Sub-watershed [(S-65E) - (S-65)]	**429,188**	**12.4**	**518,763**	**18.3**	**100.5**	**17.5**	**0.52**	**157**
Upper Kissimmee Sub-watershed (S-65)	**1,028,421**	**29.8**	**765,551**	**27.1**	**72.4**	**12.6**	**0.16**	**77**
Totals from Lake Okeechobee Watershed	**3,450,475**	**100**	**2,828,136**	**100**	**574**	**100**		
Average Values							**0.37**	**165**
Atmospheric Deposition					35			
Total Loads to Lake Okeechobee					**609**			

Note: Values shown in this table only account for contributions from the basins to Lake Okeechobee. It does not capture contributions from these basins to other basins or other surface waters.

A summary of data at the sub-watershed level is provided in **Table 8-5**. The largest surface water inflow came from the Upper Kissimmee Sub-watershed (above structure S-65), followed by the Lower Kissimmee and Indian Prairie sub-watersheds. The Upper Kissimmee Sub-watershed covers about 30 percent of the drainage area in the Lake Okeechobee Watershed, and contributes about 27 percent of total inflow during WY2014. The Lower Kissimmee Sub-watershed comprises 12 percent of the drainage area in the Lake Okeechobee Watershed and contributes about 18 percent of total inflow during WY2014. The Indian Prairie Sub-watershed covers eight percent of the drainage area in the Lake Okeechobee Watershed and discharges 17 percent of the total inflow in WY2014. The highest sub-watershed TP load comes from the Indian Prairie Sub-watershed (125 mt), followed by Taylor Creek/Nubbin Slough Sub-watershed (108 mt) and the Fisheating Creek Sub-watershed (103 mt). The highest sub-watershed unit area load of TP comes from the Taylor Creek/Nubbin Slough Sub-watershed (1.20 lb/ac, or 1.38 kg/ha), followed by the Indian Prairie Sub-watershed (0.99 lb/ac, or 1.11 kg/ha) and the Fisheating Creek Sub-watershed (0.71 lb/ac, or 0.80 kg/ha). In terms of flow weighted TP concentrations, the Taylor Creek/Nubbin Slough Sub-watershed had the highest value (457 ppb), followed by the combined East, West, and South Sub-watersheds (210 ppb) and Fisheating Creek Sub-watershed (207 ppb) during WY2014. Unlike the sub-watersheds north of the lake, the discharges to the lake from East, West, and South Sub-watersheds are highly managed based on the hydrologic and human factors. Moreover, the majority of runoff from these sub-watersheds are typically directed away from the lake. The highest surface runoff that reached the lake comes from the Indian Prairie Sub-watershed (21.3 in, or 54.1 cm), followed by Fisheating Creek Sub-watershed (15.2 inch, or 38.6 cm) and the Lower Kissimmee Sub-watershed (14.5 in, or 36.8 cm).

Table 8-5. The average surface water inflows (ac-ft), TP loads (mt) and concentration (ppb), and unit area load (lb/ac) from sub-watershed to Lake Okeechobee during WY2014.

Source	Area		Discharge		TP Load		Unit Area Load	Average TP Conc.	Runoff
	(acres)	(%)	(ac-ft)	(%)	(mt)	(%)	(lb/ac)	(ppb)	(inches)
Fisheating Creek Sub-watershed	318,042	9.2	403,020	14.3	103	18.0	0.71	207	15.2
Indian Prairie Sub-watershed	276,577	8.0	491,687	17.4	125	21.7	0.99	205	21.3
Lake Istokpoga Sub-watershed (S-68)	394,203	11.4	319,313	11.3	30	5.3	0.17	77	9.7
Lower Kissimmee Sub-watershed [(S-65E) - (S-65)]	429,188	12.4	518,763	18.3	101	17.5	0.52	157	14.5
Upper Kissimmee Sub-watershed (S-65)	1,028,421	29.8	765,551	27.1	72	12.6	0.16	77	8.9
Taylor Creek/Nubbin Slough Sub-watershed	197,795	5.7	190,904	6.8	108	18.7	1.20	457	11.6
Sub-totals for East, West and South Lake Okeechobee Sub-watersheds	806,248	23.4	138,898	4.9	36	6.3	0.10	210	2.1
Totals from Lake Okeechobee Watershed	3,450,475	100.0	2,828,136	100.0	574	100.0			
Average Values							0.37	165	9.8
Atmospheric Deposition (mt)					35				
Total Loads to Lake Okeechobee (mt)					609				

Note: Values shown in this table only account for contributions from the basins to Lake Okeechobee. The East, West, and South Lake Okeechobee Sub-watersheds drain primarily to the east, west and south, respectively. This table only represents the portion of runoff from these areas that are discharged to the lake. It does not capture contributions from these basins to other basins or other surface waters.

As shown in **Table 8-6**, during WY2014, TN load to the lake from all drainage basins and atmospheric deposition (estimated as 1,233 mt) (James et al., 2005) was 6,750 mt. The unit area load of TN averaged 1.58 lb/ac (1.77 kg/ha) for the Lake Okeechobee Watershed. At the drainage basin level, the highest unit area load of TN came L-59W basin (26.24 lb/ac, or 29.39 kg/ha), followed by the C-41A basin (19.84 lb/ac, or 22.22 kg/ha) and the L-61E basin (13.40 lb/ac, or 15.01 kg/ha) during WY2014, and all three drainage basins are located in the Indian Prairie Sub-watershed. The flow weighted TP concentration averaged 1.58 milligrams per liter (mg/L), or parts per million (ppm), for the Lake Okeechobee Watershed. The S-2 basin in the South Lake Okeechobee Sub-watershed had the highest flow weighted TN concentration (6.88 ppm), followed by the S-3 basin (3.45 ppm) in the South Lake Okeechobee Sub-watershed and the L-8 basin (2.80 ppm) in the East Lake Okeechobee Sub-watershed during WY2014.

At the sub-watershed level (**Table 8-7**), the highest TN loads came from the Indian Prairie Sub-watershed (1,281 mt), followed by the Upper Kissimmee Sub-watershed (1,175 mt) and Fisheating Creek Sub-watershed (787 mt). The highest unit area load came from the Indian Prairie Sub-watershed (10.21 lb/ac, or 11.44 kg/ha), followed by the Fisheating Creek Sub-watershed (5.46 lb/ac or 6.12 kg/ha) and Taylor Creek/Nubbin Slough Sub-watershed (5.14 lb/ac, or 5.76 kg/ha). In terms of flow weighted TN concentrations from sub-watersheds, the combined East, West, and South Lake Okeechobee sub-watersheds had the highest value (3.22 ppm), followed by the Indian Prairie Sub-watershed (2.11 ppm), and the Taylor Creek/Nubbin Slough Sub-watershed (1.96 ppm) during WY2014.

Table 8-6. WY2014 surface water inflows (ac-ft), TN loads (mt) and concentrations [milligrams per liter (mg/L), or parts per million (ppm)], and unit area load (lbs/ac) from the drainage basins to Lake Okeechobee.

Source	Area		Discharge		TN Load		Unit Area Load	Average TN Conc.
	(acres)	(%)	(ac-ft)	(%)	(mt)	(%)	(lb/ac)	(ppm)
East Lake Okeechobee Sub-watershed	**239,013**	6.9	**56,438**	**2.0**	**155.4**	**2.8**	**1.43**	**2.23**
C-44/S-153/Basin 8 (S-308 at St. Lucie Canal)	132,572	3.8	28,240	1.0	57.9	1.0	0.96	1.66
L-8 Basin (Culvert 10A)	106,440	3.1	28,198	1.0	97.6	1.8	2.02	2.80
Fisheating Creek Sub-watershed	**318,042**	9.2	**403,020**	**14.3**	**787.3**	**14.3**	**5.46**	**1.58**
Fisheating Creek at Lakeport/L-61W Basin	298,713	8.7	394,134	13.9	771.7	14.0	5.70	1.59
Nicodemus Slough North (Culvert 5)	19,329	0.6	8,886	0.3	15.6	0.3	1.78	1.42
Indian Prairie Sub-watershed	**276,577**	**8.0**	**491,687**	**17.4**	**1281.2**	**23.2**	**10.21**	**2.11**
C-40 Basin [(S-72) – (S-68)]	24,076	0.7	30,419	1.1	92.1	1.7	8.43	2.45
C-41 Basin [(S-71) – (S-68)]	112,880	3.3	98,510	3.5	338.0	6.1	6.60	2.78
C-41A Basin [(S-84) – (S-68)]	57,748	1.7	231,572	8.2	519.6	9.4	19.84	1.82
L-48 Basin (S-127 total)	20,798	0.6	16,781	0.6	47.8	0.9	5.07	2.31
L-49 Basin (S-129 total)	11,966	0.3	15,708	0.6	31.3	0.6	5.76	1.61
L-59E Basin [(G-33)+(G-34)]	12,589	0.4	15,546	0.5	43.7	0.8	7.65	2.28
L-59W Basin (G-74)	6,596	0.2	31,822	1.1	78.5	1.4	26.24	2.00
L-60E Basin (G-75)	4,944	0.1	6,290	0.2	16.2	0.3	7.23	2.09
L-60W Basin (G-76)	3,453	0.1	3,336	0.1	6.7	0.1	4.25	1.62
L-61E Basin	14,407	0.4	30,369	1.1	87.5	1.6	13.40	2.34
S-131 Basin	7,122	0.2	11,334	0.4	19.8	0.4	6.14	1.42
Taylor Creek/Nubbin Slough Sub-watershed	**197,795**	**5.7**	**190,904**	**6.8**	**461.0**	**8.4**	**5.14**	**1.96**
S-133 Basin	25,626	0.7	22,655	0.8	50.6	0.9	4.35	1.81
S-135 Basin	17,756	0.5	25,847	0.9	50.1	0.9	6.22	1.57
S-154 Basin	31,815	0.9	30,518	1.1	83.4	1.5	5.78	2.21
S-154C Basin	2,134	0.1	3,217	0.1	9.7	0.2	10.07	2.46
Taylor Creek/Nubbin Slough (S-191)	120,464	3.5	108,667	3.8	267.2	4.8	4.89	1.99
South Lake Okeechobee Sub-watershed	**363,141**	**10.5**	**81,918**	**2.9**	**396.2**	**7.2**	**2.41**	**3.92**
715 Farms (Culvert 12A)	3,353	0.1	0	-	0.0	0.0	0.00	no flow
East Beach Drainage District (Culvert 10)	6,657	0.2	0	-	0.0	0.0	0.00	no flow
East Shore Drainage District (Culvert 12)	8,409	0.2	0	-	0.0	0.0	0.00	no flow
Industrial Canal	13,024	0.4	18,516	0.7	55.5	1.0	9.40	2.43
S-2 Basin	106,274	3.1	25,989	0.9	220.5	4.0	4.57	6.88
S-3 Basin	63,134	1.8	1,396	0.0	5.9	0.1	0.21	3.45
S-4 Basin	29,121	0.8	36,016	1.3	114.2	2.1	8.64	2.57
South Florida Conservancy Drainage District (S-236)	9,931	0.3	0	-	0.0	0.0	0.00	no flow
South Shore/South Bay Drainage District (Culvert 4A)	4,036	0.1	0	-	0.0	0.0	0.00	no flow
S-5A Basin (S-352 West Palm Beach Canal)	119,202	3.5	0	-	0.0	0.0	0.00	no flow
West Lake Okeechobee Sub-watershed	**204,094**	**5.9**	**543**	**0.0**	**0.9**	**0.0**	**0.01**	**1.31**
East Caloosahatchee Basin (S-77)	198,178	5.7	0	-	0.0	0.0	0.00	no flow
Nicodemus Slough South (Culvert 5A)	5,916	0.2	543	0.0	0.9	0.0	0.33	1.31
Lake Istokpoga Sub-watershed (S-68)	**394,203**	**11.4**	**319,313**	**11.3**	**522.4**	**9.5**	**2.92**	**1.33**
Lower Kissimmee Sub-watershed [(S-65E) - (S-65)]	**429,188**	**12.4**	**518,763**	**18.3**	**737.9**	**13.4**	**3.79**	**1.15**
Upper Kissimmee Sub-watershed (S-65)	**1,028,421**	**29.8**	**765,551**	**27.1**	**1174.8**	**21.3**	**2.52**	**1.24**
Totals from Lake Okeechobee Watershed	**3,450,475**	**100**	**2,828,136**	**100**	**5,517**	**100**		
Average Values							**3.53**	**1.58**
Atmospheric Deposition					1,233			
Total Loads to Lake Okeechobee					**6,750**			

Note: Values shown in this table only account for contributions from the basins to Lake Okeechobee. It does not capture contributions from these basins to other basins or other surface waters.

Table 8-7. The average surface water inflows (ac-ft), TN loads (mt) and concentration (ppb), and unit area load (lb/ac) from sub-watershed to Lake Okeechobee during WY2014.

Source	Area		Discharge		TN Load		Unit Area Load	Average TN Conc.	Runoff
	(acres)	(%)	(ac-ft)	(%)	(mt)	(%)	(lb/ac)	(ppm)	(inches)
Fisheating Creek Sub-watershed	318,042	9.2	403,020	14.3	787	14.3	5.46	1.58	15.2
Indian Prairie Sub-watershed	276,577	8.0	491,687	17.4	1,281	23.2	10.21	2.11	21.3
Lake Istokpoga Sub-watershed (S-68)	394,203	11.4	319,313	11.3	522	9.5	2.92	1.33	9.7
Lower Kissimmee Sub-watershed [(S-65E) - (S-65)]	429,188	12.4	518,763	18.3	738	13.4	3.79	1.15	14.5
Upper Kissimmee Sub-watershed (S-65)	1,028,421	29.8	765,551	27.1	1,175	21.3	2.52	1.24	8.9
Taylor Creek/Nubbin Slough Sub-watershed	197,795	5.7	190,904	6.8	461	8.4	5.14	1.96	11.6
Sub-totals for East, West and South Lake Okeechobee Sub-watersheds	806,248	23.4	138,898	4.9	553	10.0	1.51	3.22	2.1
Totals from Lake Okeechobee Watershed	3,450,475	100.0	2,828,136	100.0	5,517	100.0			
Average Values							3.53	1.58	9.8
Atmospheric Deposition (mt)					1,233				
Total Loads to Lake Okeechobee (mt)					6,750				

Note: Values shown in this table only account for contributions from the basins to Lake Okeechobee. The East, West, and South Lake Okeechobee Sub-watersheds drain primarily to the east, west and south, respectively. This table only represents the portion of runoff from these areas that are discharged to the lake. It does not capture contributions from these basins to other basins or other surface waters.

Ambient Water Quality Data Analysis

The long-term tributary or ambient water quality stations under projects KREA and TCNS consist of river and basin-level monitoring locations that are sampled on a biweekly basis when flow is present. This analysis also considers concentration data from tributary level monitoring sites collected under project OKUSGS, initiated in 2005 (**Figure 8-4**). It is also important to note that the tributary concentration stations for C-41 and C-41A are located well upstream compared to the basin loading stations discussed earlier. TP and TN concentrations were collected at these 37 monitoring stations during WY2014. A site usually used for assessment of water quality entering the Taylor Creek STA was added to this analysis because it represents the water in Taylor Creek directly downstream of an OKUSGS site discontinued in 2009. This site now has five years of data that can be added to the long-term data set for the Taylor Creek drainage basin. Any additional long term-data within the Taylor Creek basin will be useful in the assessment of this priority basin. The ambient water quality network has primarily focused on the assessment of those basins considered critical to the nutrient concentration issues in the Lake Okeechobee Watershed (**Figure 8-4**). Additional water quality assessment in the watershed is done under the LOWA monitoring network, which supports the Works of the District Best Management Practice (BMP) Program, Chapter 40E-61, F.A.C., and the results of these efforts are discussed in Chapter 4 of this volume.

Concentration data from sites established for the Lake Okeechobee Tributary Loadings (OKUSGS) Project are included in statistical summaries (**Tables 8-8** and **8-9**). This project was formally run by the USGS under contract from the District, FDACS, and USACE and consisted of 16 locations equipped with auto-samplers programmed to collect flow-proportional samples. This project was reduced now includes two sites with auto-samplers collecting on a timed program, and five of the original stations are sampled via grab collections. Several of the OKUSGS sampling sites were leveraged against existing KREA or TCNS sites located close by. Redundancy between the two programs was eliminated once the District brought the water quality sampling in-house in 2011. Flow data from 15 of the original sites is maintained and validated by the USGS under contract from FDACS. Future reporting will summarize loadings from these tributary sites once there is enough long-term data to establish statistical significance and the historical data are verified by the District. The TN samples from unrefrigerated auto-samplers presented in this assessment should be viewed as experimental. Until recently, there was no FDEP approved method to maintain TN samples in an unrefrigerated environment over a seven-day period if the TN was calculated by adding TKN and NOx analyses. The District laboratory is now certified to analyze samples for TN directly. TN data collected via auto-sampler in the future will have much more validity. The period of record for TN is lacking from several of the basins and this data may help to provide preliminary insight into additional sources of nitrogen in the watershed.

The mean TP concentrations of the 11 basins—developed from 7 OKUSGS sites and 31 ambient (SFWMD) sites—ranged from 67 ppb at the S-65BC Basin to 629 at S-154 Basin (**Table 8-8**). For comparison purpose, data from eight-year averages for WY2006–WY2013 are also included. Due to its size and the numbers of monitoring stations, the S-191 Basin (Taylor Creek/Nubbin Slough) is further divided into two sub-basins: Taylor Creek (S-191TC) and Nubbin Slough (S-191NS). During WY2014, the highest mean TP concentration at the S-154 Basin (629 ppb) was followed by S-65E (491 ppb) and S-191TC and S191NS basins (424 ppb). Three of the four original priority basins (S-154, S-191, S65D, and S65E) continue to be problematic. The WY2014 mean TP concentrations from the C-41 basin displayed the highest percent increase (53 percent) when compared with data collected in WY2006-2013. The S-65BC had an 18 percent decrease and S-65D basins had a 17 percent decrease in TP values from WY2006–WY2013 when compared with WY2014 mean values. The first concentrations collected for WY2014 at sites located in the S-154 basin were sampled after an average of eight months between observed flows. This indicates that the first few flushes after extended periods with no flow are still consistently exhibiting very high TP concentrations in this critical basin.

TN values are calculated by adding nitrate + nitrite (NO_x) and total Kjeldahl nitrogen (TKN) concentrations. The majority of TN in the Lake Okeechobee Watershed comes from the organic form of N (TKN). The C-41 basin had the highest mean TN value (2.92 ppm) in WY2014, followed by S-154 (2.34 ppm) and S-191TC (2.33 ppm) (**Table 8-9**). The mean TN values were higher in five of the 11 basins in WY2014 as compared to the WY2006-2013 values. For the Fisheating Creek basin, TN values were 15 percent less in WY2014 as compared to WY2006–WY2013 values.

Table 8-8. Statistics of TP data collected from the ambient network in the Lake Okeechobee Watershed. WY2014 values are included to show annual changes.

BASIN	WY2006-2013 (TP)						WY2014 (TP)					
	Mean (ppb)	Median (ppb)	Std Dev	Number of Samples	Max (ppb)	Min (ppb)	Mean (ppb)	Median (ppb)	Std Dev	Number of Samples	Max (ppb)	Min (ppb)
C-41	272	183	257	194	1921	27	415	323	333	12	1011	81
C-41A	73	71	30	337	170	6	79	78	19	80	133	21
Fisheating Creek	237	193	183	409	1283	17	220	192	76	20	364	131
Lake Istokpoga	108	85	70	381	474	26	119	88	68	96	360	52
S-65A	74	66	40	377	271	23	75	65	42	36	237	25
S-65BC	82	68	43	372	273	22	67	64	20	38	125	40
S-65D	252	173	228	856	1494	11	210	125	177	74	721	43
S-65E	429	245	519	244	3330	23	491	228	593	46	2623	36
S-154	601	505	450	271	2330	14	629	630	244	29	1230	276
S191TC (Taylor Creek)	393	328	290	2064	2909	14	424	348	292	176	1737	76
S-191NS (Nubbin Slough)	428	391	259	774	2390	10	424	397	212	70	958	111

Table 8-9. Statistics of TN data collected from the ambient network in the Lake Okeechobee Watershed. WY2014 values are included to show annual changes.

BASIN	WY2006-2013 (TN)						WY2014 (TN)					
	Mean (ppm)	Median (ppm)	Std Dev	Number of Samples	Max (ppm)	Min (ppm)	Mean (ppm)	Median (ppm)	Std Dev	Number of Samples	Max (ppm)	Min (ppm)
C-41	2.29	1.98	1.08	198	5.90	0.15	2.92	2.92	1.35	12	4.59	1.37
C-41A	1.51	1.59	0.65	283	5.80	0.00	1.60	1.55	0.22	11	1.91	1.27
Fisheating Creek	2.39	2.06	1.15	377	7.90	0.29	1.92	1.77	0.41	20	2.77	1.40
Lake Istokpoga	1.40	1.38	0.31	291	2.43	0.46	1.27	1.26	0.11	23	1.48	1.09
S-65A	1.34	1.26	0.40	375	3.23	0.77	1.45	1.41	0.56	36	3.69	0.86
S-65BC	1.29	1.19	0.31	372	2.38	0.58	1.24	1.20	0.17	38	1.70	1.01
S-65D	1.64	1.56	0.55	828	6.47	0.49	1.52	1.50	0.25	71	2.18	0.93
S-65E	2.22	1.95	1.19	246	12.65	0.45	2.16	1.68	1.41	45	8.24	0.90
S-154	2.29	2.27	0.77	266	4.75	0.06	2.34	2.39	0.40	29	3.76	1.62
S-191TC (Taylor Creek)	1.96	1.78	1.12	1790	13.37	0.14	2.33	2.06	1.49	117	9.42	0.62
S-191NS (Nubbin Slough)	2.16	2.03	0.93	757	10.83	0.57	2.16	2.18	0.66	69	4.18	0.95

LAKE STATUS

PERFORMANCE MEASURES

Measurements of TP, chlorophyll *a*, phytoplankton, submerged aquatic vegetation (SAV), and water levels are used as quantitative performance measures. These measures describe the status of the ecosystem and its responses to implemented restoration programs. Measures are presented on five-year averages for consistency with the TMDL to reduce year-to-year variation due to climate and hydrology and improve understanding of underlying trends. These values are compared to established quantitative restoration goals (**Table 8-10**). The Lake Okeechobee Protection Program Report provides a technical foundation for these restoration goals (SFWMD et al., 2004). The WY2014 averaged observations document current water quality and lake level conditions.

In WY2014, pelagic nutrients were relatively lower compared to the previous years, which was an improvement. However, conditions declined in other ways. Both the total and inorganic nitrogen to phosphorus ratios declined, percent algal blooms based on chlorophyll *a* samples increased, and water clarity and SAV coverage were reduced in nearshore regions. These declines can be related to higher water levels in the lake. Of the eleven performance measures given as current five-year (WY2009–WY2013) averages, only one met its goal: the diatom-to-cyanobacteria ratio by biovolume was 1.7:1 (**Table 8-10**). This ratio was a decrease from the previous five-year average of 2.0:1.

Calculation of Secchi to total water depth ratio indicates how deep light can penetrate the water column. Generally, a Secchi depth to total depth ratio of 0.5 indicates that sufficient light is reaching the bottom to allow for the growth of SAV. However, a more stringent criterion of the Secchi Depth being visible on the bottom (a Secchi to total depth ratio of 1) is used for this performance measure. No measurements met this criterion in WY2014. This was due in part to the increased water levels from May to September compared to the previous year. The five-year average was 28 percent which is well below the target of 100 percent.

The SAV coverage goal was not reached in the WY2014 survey, but the five-year average was just below the goal of 40,000 acres. The five-year average indicated over 24,000 acres of vascular plants, which met the criterion of greater than 50 percent of the SAV being vascular taxa. (August 2009–August 2013; **Table 8-10**). A further evaluation of the last survey is provided in the *Submerged Aquatic Vegetation* section of this document.

The wet season (May to October) was wetter than normal, which resulted in 116 days of stage in excess of 15 feet; from July 15 to November 8, 2013. This length of excess stage was four days less than the 120 days which would have resulted in exceeding the high lake stage criterion. The period from November to April during WY2014 was dry, which allowed the lake stage to decline and to partially attain a second performance measure: spring recession. With the exception of one reversal from late January 2014 to mid-February 2014, the stage declined gradually from January to May 2014, but increased after June 9, 2014, as the wet season began (data not shown). Lake stage also remained above the 10-foot goal throughout the year meeting the low lake stage criterion.

Table 8-10. Summary of Lake Okeechobee rehabilitation performance measures, rehabilitation program goals, and lake conditions for WY2013, WY2014, and the five-year average (WY2011–WY2014).

Performance Measure	Goal	Five-Year Average	WY2014	WY2013
Total Phosphorus (TP) load	140 mt/yr	442 mt/yr	609 mt/yr	569 mt/yr
Total Nitrogen (TN) Load	N/A	5,401 mt/yr	6,750 mt/yr	6,397 mt/yr
Pelagic TP	40 ppb	115 ppb	118 ppb	124 ppb
Pelagic TN	N/A	1.41 ppm	1.28 ppm	1.44 ppm
Pelagic SRP	N/A	38 ppb	30 ppb	42 ppb
Pelagic DIN	N/A	178 ppb	139 ppb	208 ppb
Pelagic TN:TP	> 22:1	12.2:1	10.8:1	11.6:1
Pelagic DIN:SRP	> 10:1	4.7:1	4.6:1	5.0:1
Plankton nutrient limitation	Phosphorus >Nitrogen	Nitrogen >>> Phosphorus	Nitrogen >>> Phosphorus	Nitrogen >>> Phosphorus
Diatom:cyanobacteria ratio [a]	> 1.5	2.0	1.7	2.7
Algal bloom frequency	< 5% of pelagic chlorophyll *a* exceeding 40 µg/L	7.2%	14%	1.2%
Water clarity	Secchi disk visible on Lake bottom at all nearshore SAV sampling locations from May–Sep	28%	0%	55%
Nearshore TP	Below 40 ppb	115 ppb	114 ppb	77 ppb
Submerged aquatic vegetation (SAV)[b]	Total SAV > 40,000 acres	38,335 acres total	33,854 acres Total	47,692 acres Total
	Vascular SAV > 50% of total acres	64%	83%	63%
Extremes in low lake stage (current water year)	Maintain stages above 10 ft	N/A	Goal attained	Goal attained
Extremes in high lake stage (current water year)	Maintain stages below 17 ft; stage not exceeding 15 ft for more than 4 months	N/A	Goal attained	Goal attained
Spring recession (January to June 2013)	Stage recession from near 15.5 ft in January to near 12.5 ft in June	N/A	Goal partially attained (January stage just over 14 ft to 12.98 ft in June; a reversal occurred in June)	Goal partially attained (within 0.5 ft from January to May; a reversal occurred in June)

[a] Mean values from May 2009 to February 2013

[b] Mean yearly acreages (from August 2008–2013 maps)

N/A - Not available

[c] SAV transparency readings taken from May to September 2013

HYDROLOGY

Lake Okeechobee water levels began WY2014 at an elevation of 13.44 ft (4.10 m) NGVD, which placed water levels in the Low Lake Management Sub-Band (**Figure 8-5**). Regulatory discharges from the lake to the estuaries were made until October 21, 2013 based on 2008 LORS schedule (SFWMD, 2010). These discharges were primarily to the Caloosahatchee River, followed by the St. Lucie Estuary as well as to south through the S-351, S-352, and S-354 structures (see Volume III, Appendix 4-1, Table 7). Lake stage increased almost three feet from June to August. After October 21, 2013, a combination of base flow and regulatory releases to the WCAs and some pulse releases to the estuaries were made. Lake stage increased to 16.05 ft NGVD by August 10, 2013, and remained high until October 2013. At that point, the stage began to decline due to drier than average rainfall conditions (see Volume III, Appendix 4-1, Table 8). A reversal of 0.3 ft occurred over the period from January 30–February 14, 2014. Water levels ended on April 30, 2014, at a stage of 13.07 ft NGVD.

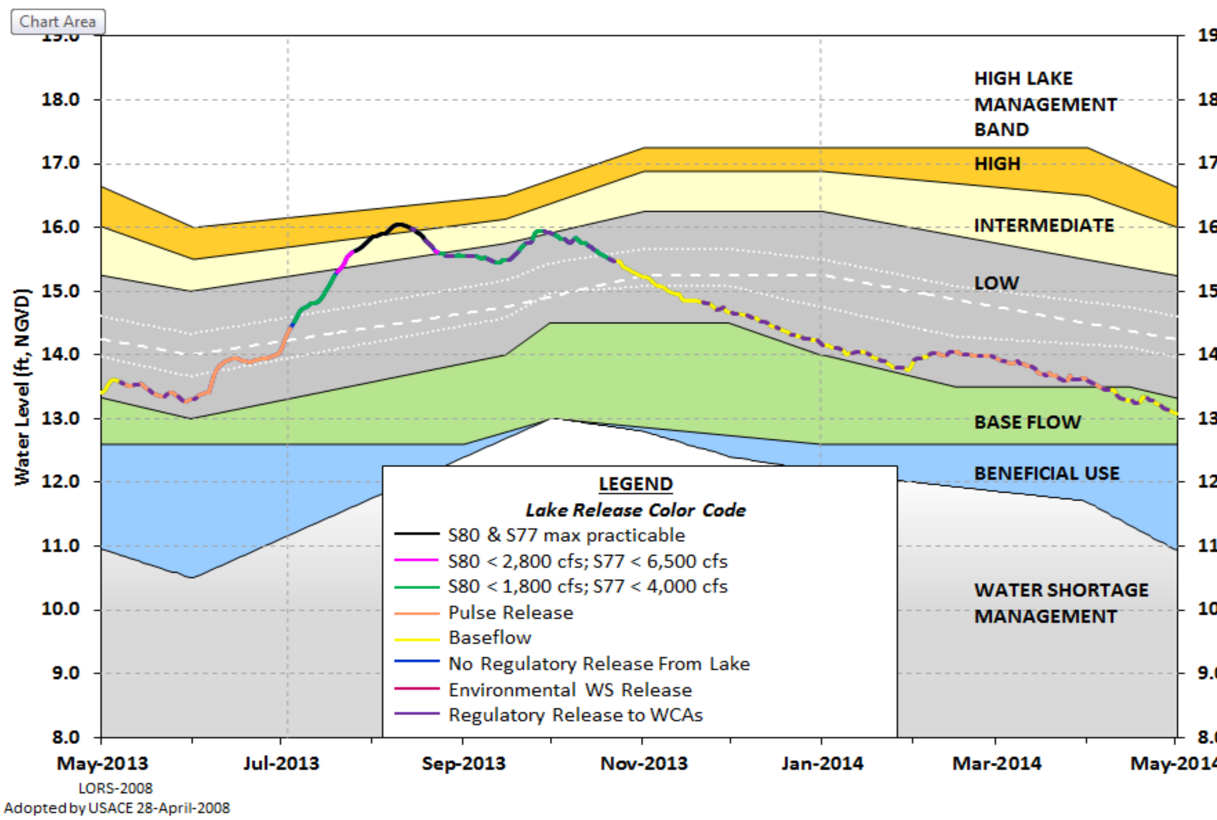


Figure 8-5. Annotated Lake Okeechobee stage (in ft NGVD) hydrograph.

NUTRIENT BUDGETS

TP loads to the lake from tributaries and atmospheric deposition (estimated as 35 mt/yr; FDEP, 2001) totaled 609 mt in WY2014 (**Table 8-11** and **Figure 8-6**). This was 7 percent more than the previous water year and is attributable to the 31 percent higher flow; primarily from the northern basins (see Volume III, Appendix 4-1, Tables 6 and 14). Mean lake TP mass in WY2014 was slightly higher than the previous water year due to a slightly higher water volume (**Table 8-11** and **Figure 8-7**). Loads out of the lake in WY2014 were higher than in WY2013 as discharge was higher. The net load (inputs minus outputs) in WY2013 was 277 mt. Sediment accumulation was higher than the previous year resulting in a net sedimentation coefficient of 0.57 (**Table 8-11 and Figure 8-8**). The net sedimentation coefficient, σ_y (per year), of the phosphorus budget is the amount of TP that accumulates in the sediment per year divided by the average lake water TP mass (**Table 8-11** and **Figure 8-8**). A low σ_y indicates that the lake absorbed less excess TP load from the watershed.

Phosphorus concentrations in the water column declined from a high of 233 ppb in WY2005 to 93 ppb in WY2012. The current WY2014 value is 118 ppb which is higher than the WY2012 value but lower than the WY2013 value (**Figure 8-7**). The higher values in WY2013 and WY2014 can be attributed to both the increased loads and higher water levels as compared to WY2012. Increased water levels reduce light penetration, potentially resulting in a decline in SAV which in turn may affect nutrient removal from the water column. Higher water levels also increase exposed areas of open water and consequently may promote more resuspension of sediment and its related phosphorus.

Table 8-11. TP budget (mt) for Lake Okeechobee for the most recent 10 water years.

May 1–April 30 Water Year	Mean Lake TP Mass	Net Change in Lake Content[a]	Load (mt) In[b]	Load (mt) Out	Net (mt) Load[c]	Sediment Accumulation[d]	Net Sedimentation Coefficient (σ_y)
2005	1108	270	960	582	378	108	-0.01
2006	1104	-194	795	798	-3	191	0.26
2007	593	-269	203	176	27	296	0.49
2008	462	132	246	26	220	88	0.48
2009	602	-276	656	242	414	690	0.63
2010	490	291	478	77	401	110	0.50
2011	428	-338	177	208	-31	307	0.49
2012	307	10	373	88	285	275	1.30
2013	530	241	569	126	443	202	0.33
2014	542	-34	609	332	277	311	0.57
Average	617	-0.7	507	266	241	242	0.47

[a] Net change from the start (May 1) through the end (April 30) of each water year

[b] Includes 35 mt/yr to account for atmospheric deposition

[c] Difference between load in and load out

[d] Difference between net change in lake content and net load (positive value is accumulation in sediments)

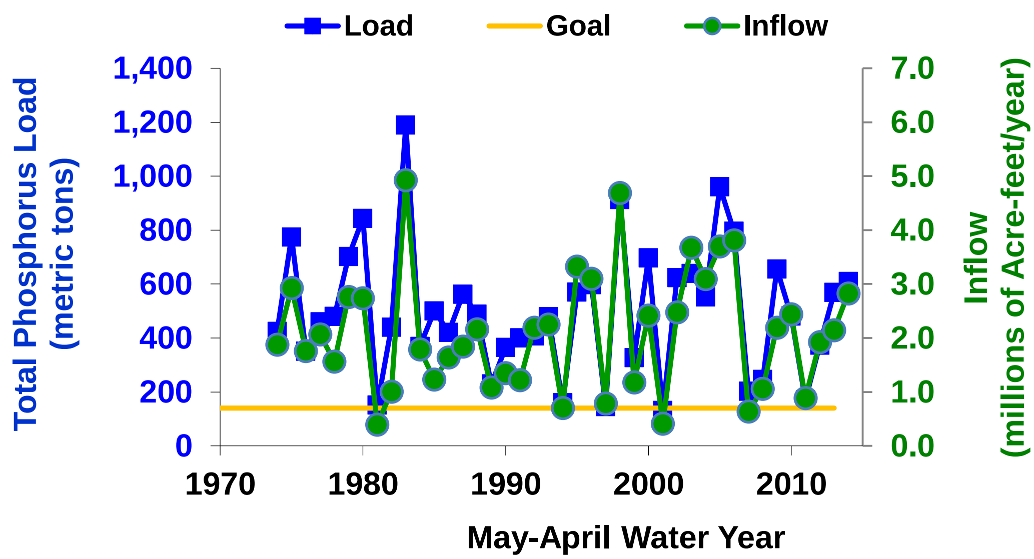


Figure 8-6. Timeline of inflow and lake average TP concentrations (five-year moving average trend lines calculated from the TP budget of the lake).

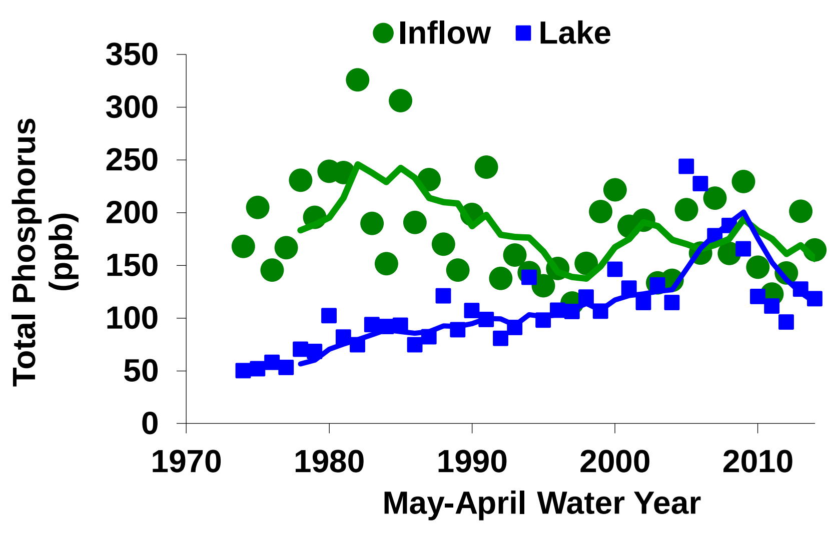


Figure 8-7. Timeline of water year TP load and inflow entering Lake Okeechobee from its tributaries calculated from the TP budget of the lake.

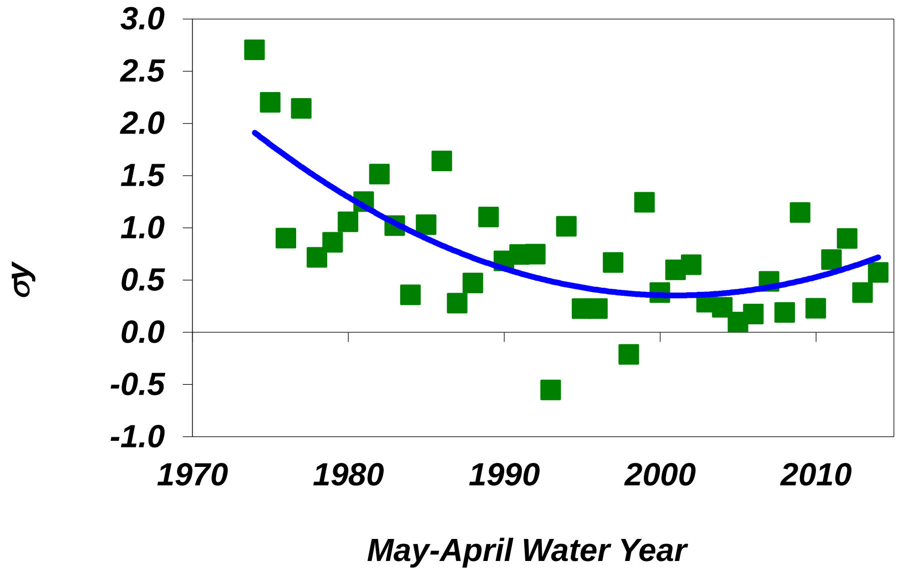


Figure 8-8. Timeline of the net sedimentation coefficient (σ_y) calculated from the phosphorus budget of Lake Okeechobee. [Trend line is a second-order polynomial.]

For WY2014, the sediment coefficient (σ_y) value is 0.57 per year (**Table 8-12**), which is higher than the 10-year average value of 0.49 per year. The WY2014 is also higher than the previous year value primarily because of the small change of storage in the lake water column in WY2014. Over the past four decades σ_y declined from around 2.5 in the 1970s to below 1 in the 1990s (**Figure 8-8**; Janus et al., 1990; James et al., 1995; Havens and James, 2005). It appears that the values are again increasing.

Loads of nitrogen to the lake are approximately tenfold greater than phosphorus (**Table 8-12**), which generally reflects the typical ratio of N to P in living systems. Annual loads also are closely related to the hydrology of the lake, fluctuating between 2,500 and 14,000 mt/year (**Figure 8-9**). Discharge nitrogen loads from the lake are approximately half of the inflow loads (**Table 8-12**). Inflow nitrogen concentrations tend to be higher than either in-lake or outflow concentrations while outflow concentrations tend to be slightly higher than in-lake concentrations (**Figure 8-10**). This is probably a result of the intra-annual variability of nitrogen in the lake, with higher nitrogen levels in winter than in summer (Maceina and Soballe, 1990), and increased discharge of water in the late winter and spring.

Despite this difference between loads into and out of the lake, concentrations of nitrogen in the lake have been relatively stable since the 1980s (**Figure 8-10**). This stability is likely due to biological processes in the lake that remove nitrogen through the denitrification process (James et al., 2011). Evidence of this uptake is observed in the lake adsorption rate, which averages almost 50 percent of the load into the lake (**Table 8-12**).

Table 8-12. Total nitrogen (TN) budget (mt) for Lake Okeechobee for the most recent 10 water years.

May 1–April 30 Water Year	Mean Lake TN Mass	Net Change in Lake Content[a]	Load In[b] (mt)	Load Out (mt)	Net Load[c] (mt)	Lake Adsorption[d]	Net Adsorption Coefficient (σ_y)
2005	10,023	2,588	8,775	6,609	2,166	-422	-0.04
2006	9,389	-2,692	7,992	8,048	-56	2,636	0.28
2007	4,873	-3,460	2,965	2,023	942	4,402	0.90
2008	3,772	2,128	3,393	392	3,001	873	0.23
2009	6,566	-1,075	6,689	2,841	3,848	4,923	0.75
2010	6,659	2,735	6,325	1,106	5,219	2,484	0.37
2011	5,762	-3,402	2,913	3,018	-105	3,297	0.57
2012	4,427	487	4,620	1,460	3,160	2,673	0.60
2013	6,178	1,705	6,397	1,879	4,518	2,813	0.46
2014	5,900	-81	6,750	4,258	2,492	2,573	0.44
Average	**6,355**	**-107**	**5,682**	**3,163**	**2,519**	**2,625**	**0.46**

[a] Net change from the start (May 1) through the end (April 30) of each water year

[b] Includes 1233 mt/yr to account for atmospheric deposition

[c] Difference between load in and load out

[d] Difference between net change in lake content and net load (positive value is adsorption from water column)

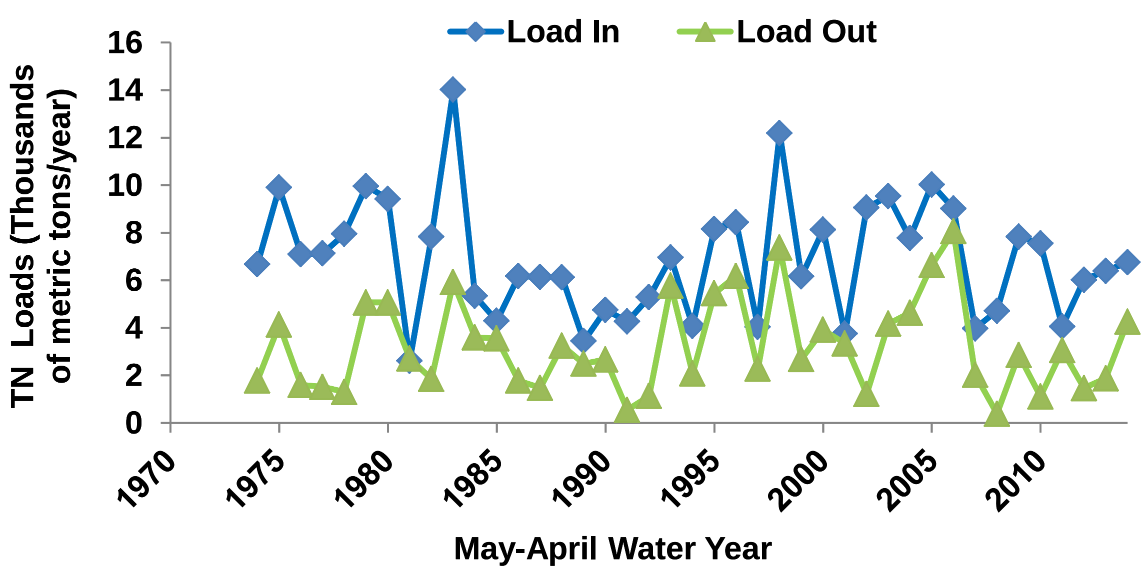


Figure 8-9. Timeline of water year inflow and outflow TN load to and from Lake Okeechobee calculated from the nitrogen budget of the lake.

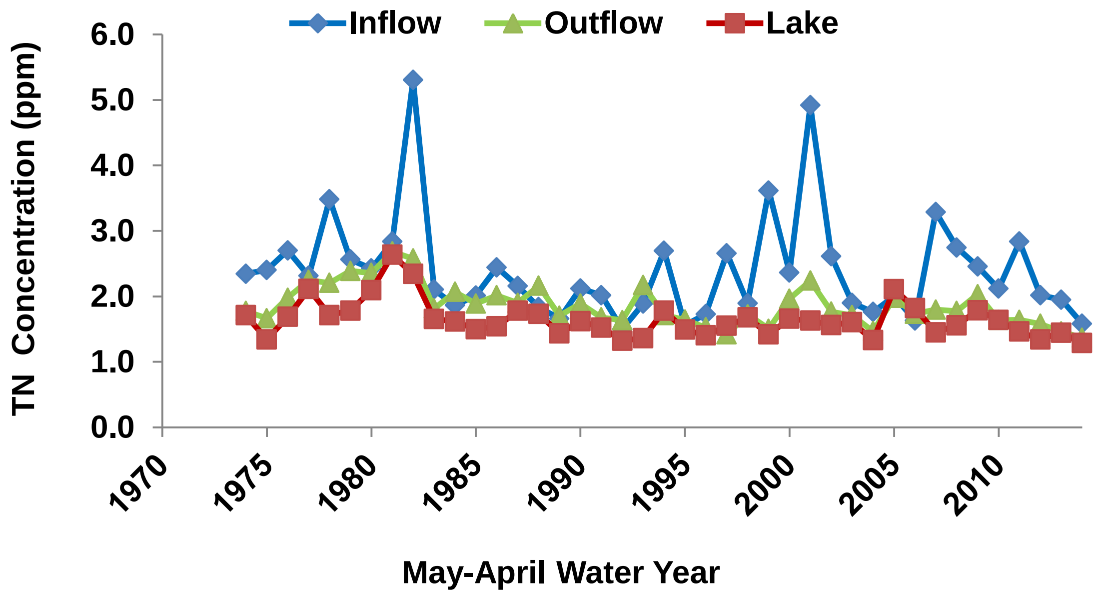


Figure 8-10. Timeline of inflow, outflow, and lake average TN concentrations calculated from the nitrogen budget of Lake Okeechobee.

LAKE OKEECHOBEE MONITORING RESULTS

SUBMERGED AQUATIC VEGETATION

Submerged aquatic vegetation (SAV) abundance, a key indicator of the lake's overall ecological health, has been routinely monitored on Lake Okeechobee since WY2000. SAV is sampled in two ways that vary in temporal and spatial scale. On a yearly basis, the entire nearshore and marsh zones of the lake are mapped to determine the spatial extent of each SAV species. On a quarterly basis, SAV is sampled at a subset of these annual sites that extend along transects from the shoreline to deeper water in the south, west, and north nearshore zone. Further details of current methods and sampling sites are presented in the 2012 and 2013 SFER – Volume I, Chapter 8 (Zhang and Sharfstein, 2012 and 2013).

Results

Over the past two years, areal coverage, as measured in August of each year, has decreased from 47,692 ac (19,300 ha) to 33,854 ac (13,700 ha) (**Figure 8-11**). Much of this reduction was due to a decrease in the non-vascular macro-alga, *Chara* spp.; which decreased from 23,475 ac (9,500 ha) in WY2013 to 8,402 ac (3,400 ha) in WY2014. *Utricularia* spp. and *Ceratophyllum* spp. are the only species that increased in areal coverage in WY2014. Vascular species accounted for 83 percent of the total acres of SAV in WY2014 as compared to 67 percent in WY2013 while the non-vascular *Chara* spp. accounted for 17 percent in WY2014 as compared to 33 percent in WY2013 (**Figure 8-12**). In the nearshore zone, *Utricularia* spp. (13,838 ac, or 5,600 ha) dominated the vascular species in WY2014, followed by *Hydrilla verticillata* (10,131 ac, or 4,100 ha), *Ceratophyllum* spp. (9,143 ac, or 3,700 ha), *Vallisneria americana* (4,695 ac, or 1,900 ha), *Najas guadalupensis* (2,224 ac, or 900 ha), and *Potamogeton* spp. (1,483 ac, or 600 ha)**.**

The decrease in aerial coverage of SAV that occurred between WY2013 and WY2014 is not surprising as lake stage during the latter sampling event was approximately 3.75 ft higher. The stage in August WY2014 was 15.86 ft NGVD compared to 12.12 ft NGVD in August WY2013. Additionally, lake stage increased almost three feet from June–August, the peak growing season. The apparent result was a loss of *Chara* at the more offshore sites and a simultaneous increase in *Utricularia* at more inshore sites. One possible reason for the decrease in *Chara* in the nearshore zone was uprooting from increased wave action because of the increased water depths. However, it is also possible that the loss was due to reduced bottom light climate, or that beds were simply missed during sampling since the equipment used cannot reach deeper than about 2 m.

Utricularia has consistently been a major component of the nearshore vascular SAV community since the implementation of LORS 2008, which resulted in lower average lake stages. The one exception was during the low lake stages of WY2012 when *Utricularia* disappeared when much of the area where it is typically found became dry. One possible reason for its upsurge is that the lower lake stages resulting from recent climatology and the LORS 2008 schedule have resulted in previously SAV-dominated areas in the nearshore zone being replaced by emergent plants. Due to its ability to fix nitrogen and feed carnivorously, *Utricularia* is uniquely adapted to low nutrient conditions that are typical of marsh areas surrounded by dense emergent plants that compete for nutrients and effectively block out interaction with the higher nutrient pelagic zone water.

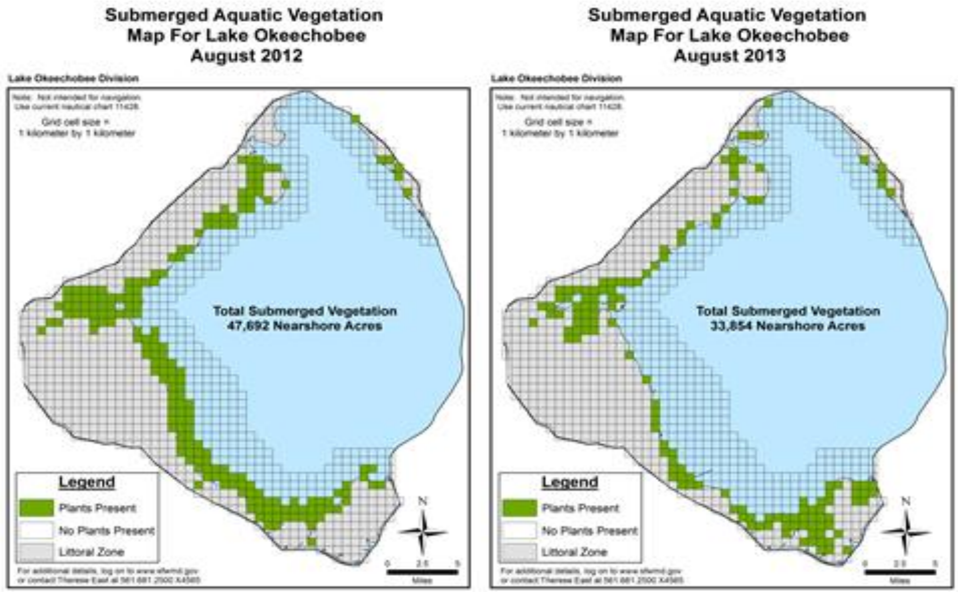


Figure 8-11. Annual SAV mapping results for WY2013 and WY2014.

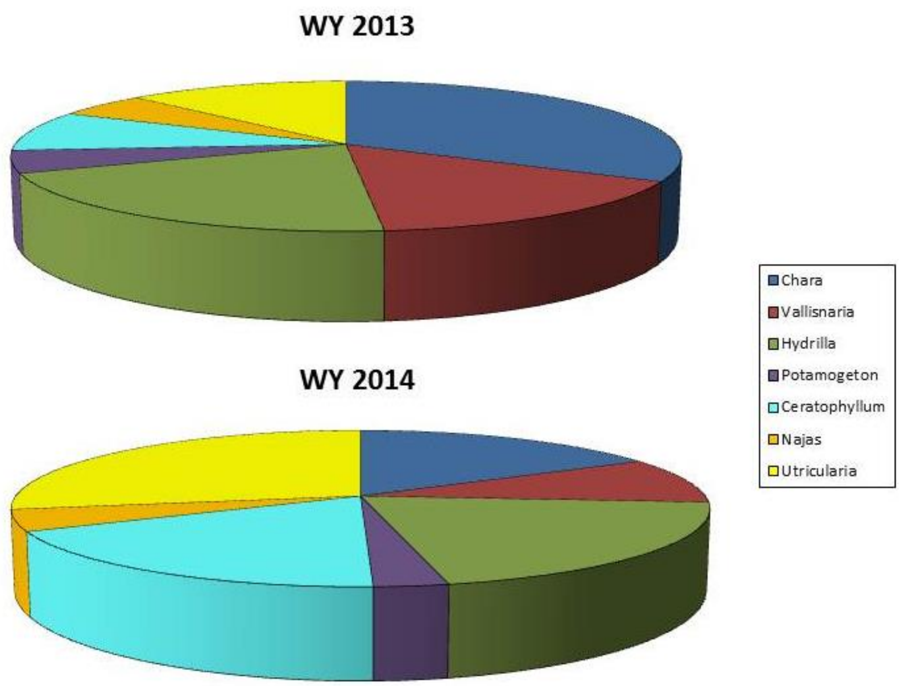


Figure 8-12. Percent of total acres for each SAV species for WY2013 and WY2014. Vascular species include *Vallisneria americana*, *Hydrilla verticillata*, *Potamogeton* spp., *Ceratophyllum* spp., *Najas guadalupensis, and Utricularia* spp*. Chara* spp. is the only non-vascular species*.* Sampling was conducted in August of each year.

Results from the quarterly transect grid cells show that the SAV community in Lake Okeechobee has remained relatively stable over the past three to four years (**Figure 8-13**). A seasonal pattern in the SAV community is also evident with more vegetated sites in August and fewer vegetated sites during the fall and winter sampling periods. The lower lake stage in WY2013 resulted in more dry and inaccessible sites than in WY2014 when lake stage was almost four feet higher. Of the fifty four sites that are sampled each quarter, sixteen sites were inaccessible at the lower lake stage compared to only six inaccessible sites at the higher lake stage. This demonstrates one of the limitations of the quarterly sampling program since, unlike the annual mapping where the set of grid cells sampled moves shoreward or lakeward depending on the lake stage at the time of sampling, the set of quarterly sites is geographically fixed so that some sites in the series may become too dry or too deep to sample at various lake stages.

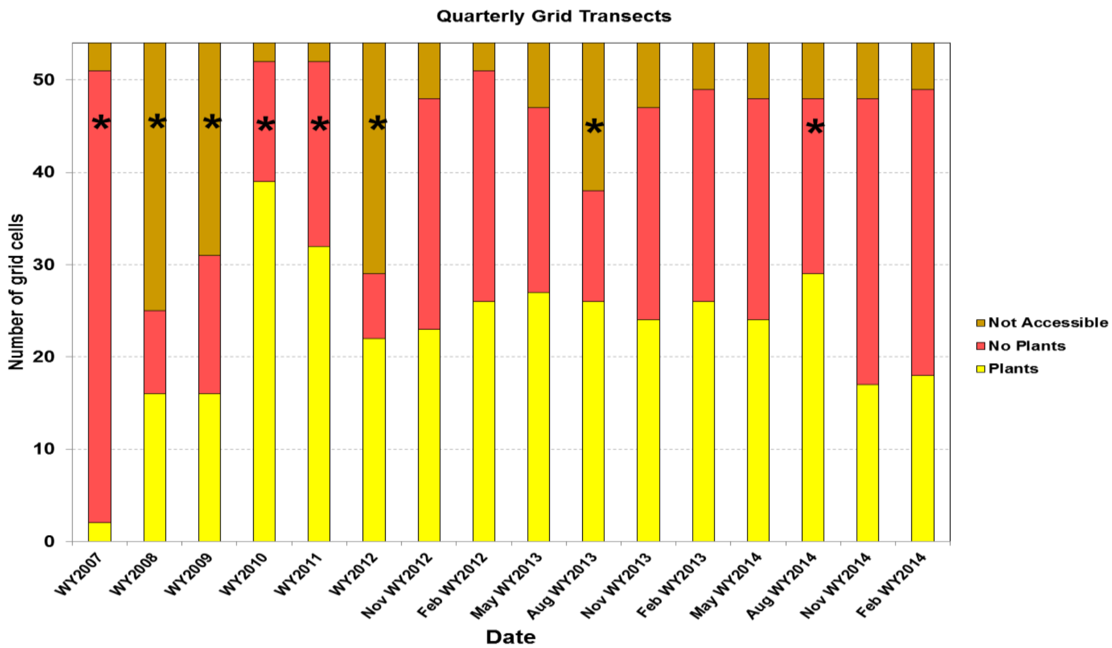


Figure 8-13. Number of grid cells with plants, without plants and that were inaccessible (dry, or too much terrestrial or emergent vegetation) for the 54 sites along the 7 transects on an annual basis from WY2007–WY2012 (***data from the August annual mapping grid cells) and on a quarterly basis from November WY2012–May WY2014.

Although SAV mapping in the marsh (**Figure 8-14**) began in WY2011 and there were over 11,000 ac (4,450 ha) of SAV present, lake levels were so low in WY2012 and WY2013 that the marsh was dry and inaccessible. Due to the higher lake stage of WY2014, many more marsh grids were accessible and this resulted in the highest total marsh SAV acreage to date (27,923 ac, or 11,300 ha). Additionally, and in contrast to the WY2011 sampling effort, sites in the very interior areas of the marsh that were not navigable by boat were visited by helicopter to get a better estimate of the SAV habitat within these boundaries. Observations made from the air confirmed the assumption that many of those grid cells primarily consisted of woody or terrestrial vegetation but often also had ponds that contained SAV, most often *Utricularia* spp. In WY2011, 38 of 66 (57 percent) marsh sites contained *Utricularia* spp., which increased substantially to 93 of 113 (82 percent) marsh sites in WY2014.

The WY2014 nearshore SAV coverage of 33,854 ac (13,700 ha) did not meet the RECOVER performance measure of greater than 40,000 ac (16,181 ha) of total SAV (**Table 8-10;** RECOVER, 2014). However, 83 percent of the total SAV was composed of vascular species which met the metric that at least half of the total acreage be comprised of vascular species

The higher lake stage during the summer of WY2014 did not result in the reduction of the approximately 7,000 ac of emergent aquatic vegetation (EAV) in the south end of the lake that was formerly SAV habitat. However, cattail along the littoral fringe of the western marsh was uprooted; potentially creating habitat available for colonization by SAV or other emergent species. Although lake stage has remained at the low end of the preferred stage envelope over the past six years, areal SAV coverage is markedly better than it was during the prolonged high lake stages that characterized the mid-to-late 1990s and the years immediately following the 2004 and 2005 hurricanes.

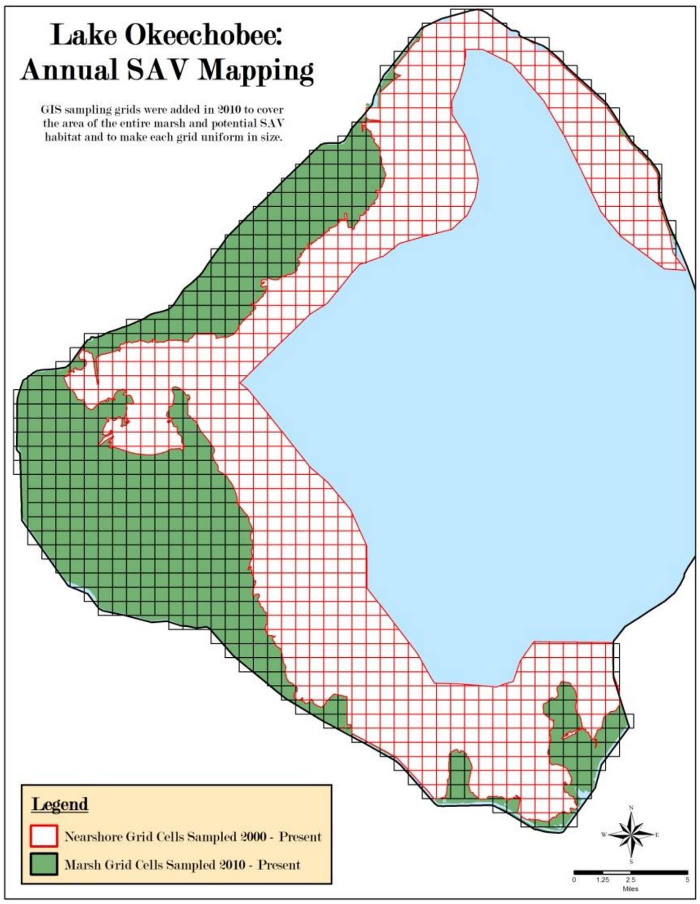


Figure 8-14. Geographic areas defined as marsh and nearshore SAV sites. The grid cells outlined in red are the nearshore grid cells that have been sampled since 2000 (WY2001). The grid cells outlined in black are the marsh grid cells that were added in 2010 (WY2011). Grid cell size = 1km^2.

LAKE OKEECHOBEE EMERGENT VEGETATION MAPPING

The emergent marsh in Lake Okeechobee provides habitat for fish, wading birds, and other wildlife. Annual monitoring and mapping of the dominant plant communities provides a quantifiable method to monitor and evaluate temporal changes that occur across the marsh landscape. The composition, distribution, and areal coverage of the plant communities in the marsh are strongly influenced by hydrologic conditions, vegetation management actions, and competition between species, especially when native habitats are affected by invasive exotic plants. To determine how Lake Okeechobee's emergent marsh community responds to these influences, detailed vegetation maps of the dominant and sub-dominant plant communities in the marsh are developed on a regular basis. Because of the vast size of the lake's marsh (> 40,000 ha), it is not feasible to map the entire marsh annually. Therefore, in years when the entire marsh is not mapped by aerial photography, sentinel plant communities in the upper, mid, and lower elevation marsh are mapped by airboat and helicopter (see Bertolotti et al., 2014 for a detailed description of the choice of sentinel sites and sampling methodology used). The sentinel sites were chosen because they were considered representative of the entire marsh. These sites provide an alternative means to detect and quantify spatial and temporal changes in plant communities (wildlife habitat) that occur in response to changing environmental conditions.

During the five-month period (January 1–May 31, 2014) prior to the most recent sentinel mapping, hydrologic conditions in the marsh were drier when compared to the January–May 2013 period (**Figure 8-15**). Lake stage never exceeded 14.49 ft NGVD during the January–May 2014 period and remained below 13 ft NGVD 15 percent of the time. As a result, much of the upper marsh remained dry and some areas of the mid marsh became exposed (dried out) as well during this five-month period.

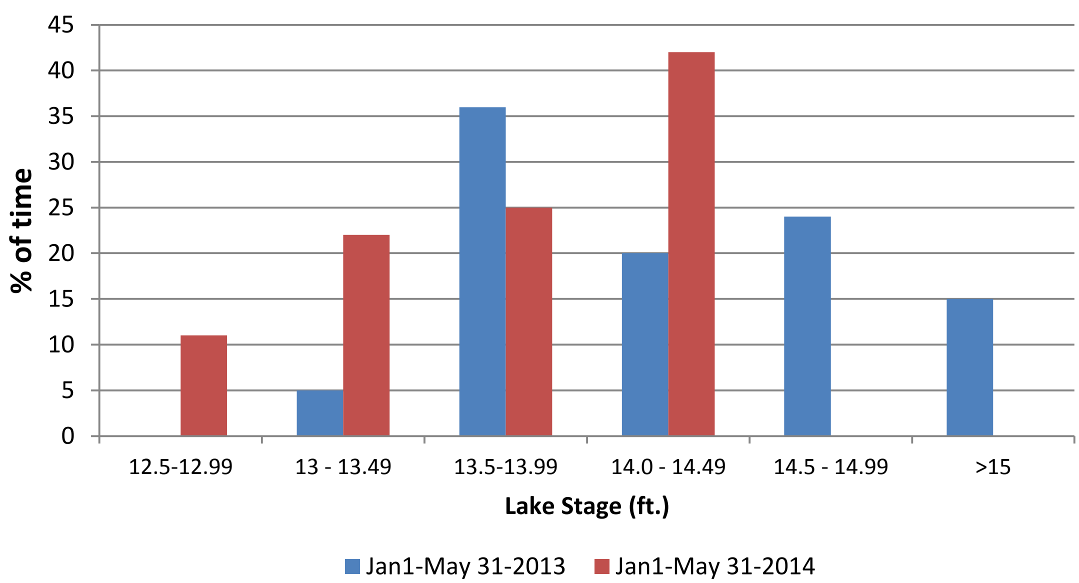
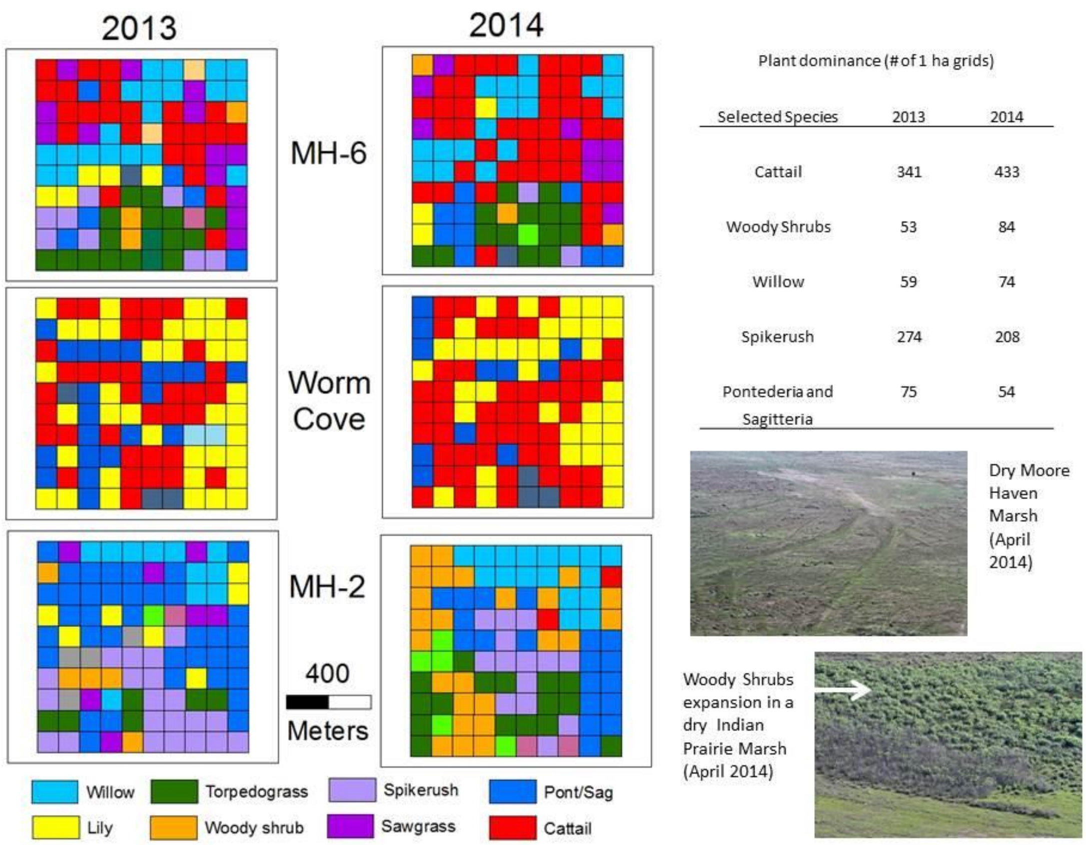


Figure 8-15. Lake stage recorded at LZ40 during the five-month periods from January 1–May 31, 2013 (blue bars) and January 1–May 31, 2014 (red bars).

In 2013, cattail (*Typha* sp.) was the dominant plant species in 341 of the 1,550 grids sampled. Cattail dominance increased to 28 percent (433 grids) of the total area in 2014. In addition to the 2014 increase in cattail, the dry marsh condition led to a 58 percent increase in woody shrub species including buttonbush (*Cephalanthus occidentalis*), saltbush (*Atriplex pentandra*), and swamp hibiscus (*Hibiscus grandiflorous*), and a 25 percent increase in willow (*Salix caroliniana*). The expansion of woody species in the upper marsh and cattail in the mid marsh occurred mostly at the expense of spikerush (*Eleocharis cellulosa*) and beakrush (Rhynchospora sp.), which were reduced 24 percent and 10 percent, respectively. Pickerelweed (*Pontederia cordata*) and duck potato (*Sagittaria lancifolia*), both also declined by 28 percent (**Figure 8-16**). Each of the mapped sites was 1 km^2 in size. At site MH-6 (upper panel) cattail dominance increased from 24 grids in 2013 to 40 grids in 2014 while cattail at Worm Cove (mid panel) also increased from 36 grids in 2013 to 49 grids in 2014. At MH-2 (lower panel) woody shrub dominance increased from 5 grids in 2013 to 24 grids in 2014 and willow dominance increased from 11 to 17 grids. As the distribution of woody species increased at MH-2, the dominance of spikerush and duck potato declined by more than 30 percent.



Plant dominance (# of 1 ha grids)

Selected Species	2013	2014
Cattail	341	433
Woody Shrubs	53	84
Willow	59	74
Spikerush	274	208
Pontederia and Sagitteria	75	54

Figure 8-16. Vegetation maps for three of the 1 km^2 sentinel study sites (MH-6, Worm Cove, and MH-2) in the Lake Okeechobee littoral marsh. Temporal changes in the dominant vegetation were primarily caused by changes in hydrologic conditions and quantified in the inserted table. Insert pictures show dry conditions and expanding woody shrubs (buttonbush) in the upper marsh in April 2014.

EXOTIC SPECIES CONTROL PROGRAM

The Exotic Species Control Program is designed to identify the exotic species that threaten native flora and fauna within the Lake Okeechobee Watershed, and to develop and implement measures to protect native species. The exotic plants and animals identified as threatening native species will require management or in the case of some animal species, monitoring of possible future invasions.

The District's exotic and nuisance vegetation management program is designed to protect threatened native habitat in Lake Okeechobee and to restore areas of the marsh that have been impacted by non-desirable species. Torpedograss (*Panicum repens*) is the most common emergent exotic plant in the lake's marsh and extensive efforts to reduce its coverage have been made. An evaluation of recent and historical torpedograss treatments dating as far back as 2009 indicated that many of the treatments provided excellent torpedograss control (> 90 percent), some for 5 years following a single treatment. Of the 20 treatment sites evaluated, control of torpedograss (treatment efficacy) was rated as 90 percent or greater at 12 sites, 50–89 percent at two sites, 25–49 percent at 4 sites and less than 25 percent at 2 sites (**Figures 8-17** and **8-18**).

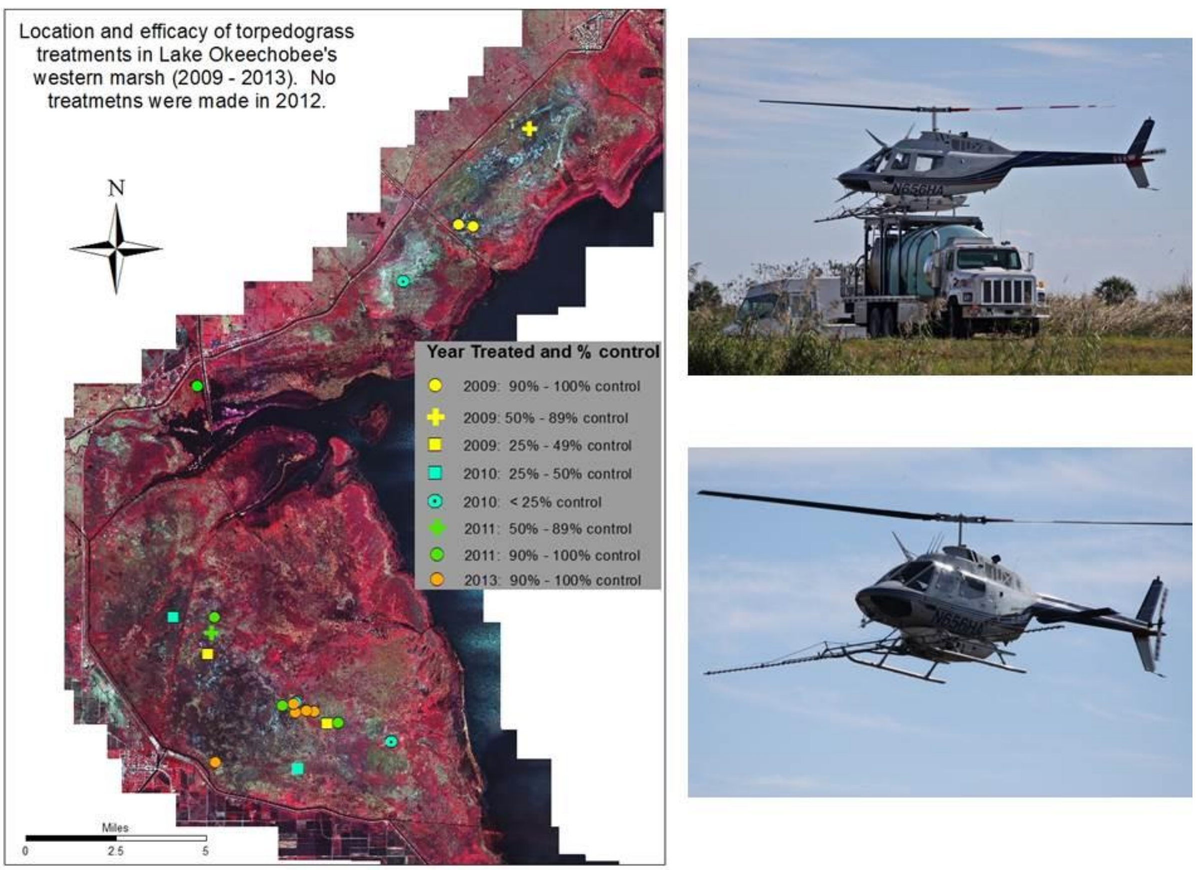


Figure 8-17. The location and efficacy of torpedograss treatments in the Lake Okeechobee western marsh. Colors indicate the year of treatment(s) and the symbol indicates treatment efficacy evaluated as percent control.

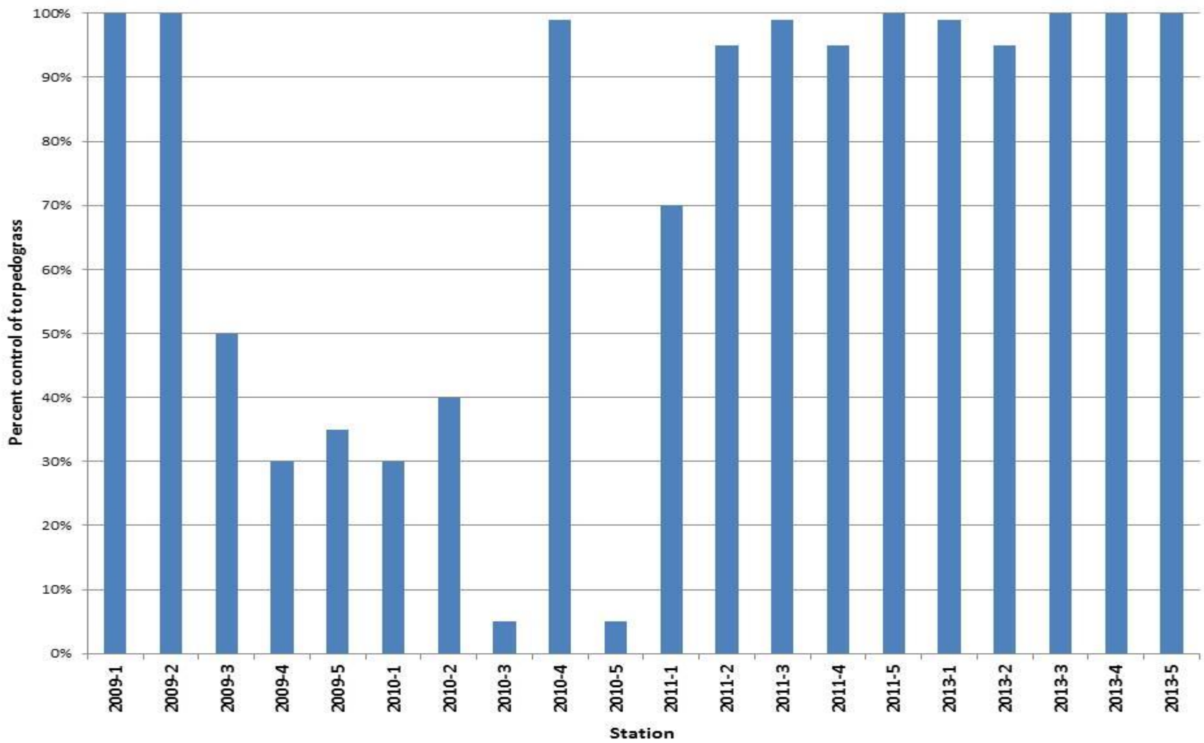


Figure 8-18. Treatment efficacy ratings by site shown as percent control of torpedograss. The five evaluation sites selected for each year were all greater than 3 ha in size.

When evaluated in early summer 2014, treatment efficacy was rated as 95 percent or greater at all of the 2013 evaluation sites and at four of the 2011 sites (no treatments were made in 2012). Efficacy dropped to 40 percent or less at 4 of the 2010 sites. The high level of control recorded at site 2010–2014 resulted from the site being retreated in 2013. Control remained high (100 percent) in two of the 2009 treatment sites, moderate at one site and poor at two sites.

Torpedograss treatments reduce the occurrence of dense monocultures of torpedograss that provide limited habitat for wading birds and harvestable sport fish. When torpedograss is removed native plants commonly recolonize treated sites. For example, the native plants spikerush (*Eleocharis cellulosa*) and fragrant water lily (*Nymphaea odorata*) are now the dominant plants at the sites where torpedograss was treated in 2011. Removing torpedograss and reestablishing shallow open water sites that include a mixture of native vegetation can provide productive foraging habitat for wading birds. This was observed in a number of sites throughout the marsh during the 2014 wading bird survey **(Figure 8-19**).

Figure 8-19. Hundreds of white ibis, glossy ibis, and other wading birds were observed foraging in native spikerush (*Eleocharis cellulosa*) habitat in the Moore Haven marsh during January 2014. Spikerush is one of the productive native habitats most often threatened or replaced by the exotic species torpedograss.

During October 2012–September 2013 (FY2013), 196 ac of torpedograss were treated. In addition, 406 ac of tropical American water grass (*Luziola subintegra*), 305 ac of cattail, and 5 ac of melaleuca (*Melaleuca quinquenervia*) also were treated **(Figure 8-20**).

While there is an ongoing need to treat thousands of acres of torpedograss in Lake Okeechobee's interior marsh, during the past several years, new infestations of torpedograss have established near the outer edge of the marsh. These infestations also require treatment as they result in the loss of important and productive fish habitat in an area heavily utilized by anglers.

In the preceding decade thousands of acres of torpedograss were treated in many years, resulting in overall excellent control of this invasive exotic in the Lake Okeechobee littoral zone. However, the expansion of torpedograss is an ongoing problem and one that will require a continuing large-scale control effort if earlier gains are to be maintained.

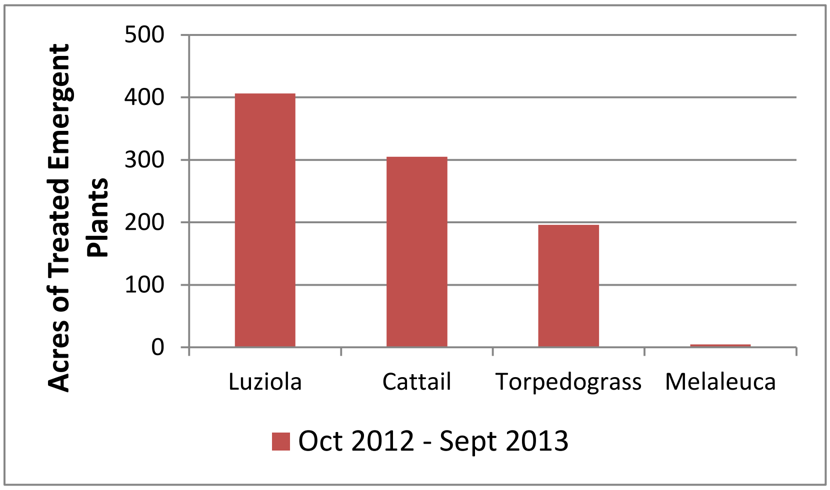


Figure 8-20. Number of acres of exotic or invasive plants in the Lake Okeechobee western marsh that were treated between October 2012 and September 2013.

WADING BIRD SURVEYS

Wading bird foraging has been monitored in Lake Okeechobee since 2010. These data can be used as indicators of habitat quality and provide an important tool for examining the effects of hydrology, restoration efforts, and changes in the trophic levels that constitute the prey base. This monitoring can also provide insight into habitat suitability and utilization based on climatology and water management decisions and it allows for an overarching assessment of ecological conditions within the lake. It also provides important supporting data for the annual Lake Okeechobee wading bird nesting surveys carried out by Florida Atlantic University under RECOVER efforts.

Methods

Wading bird surveys were increased to once every two weeks beginning in December 2013 and continuing through June 2014 along east-west transects established at 2 kilometer (km) intervals throughout the entire littoral zone of Lake Okeechobee. Prior to March 2013 these surveys were only conducted on a monthly basis. Further details regarding survey methods are described in the 2012 SFER – Volume I, Chapter 8 (Zhang and Sharfstein, 2012).

Results

The WY2014 survey flights began in December 2013 with a lake stage of 14.6 ft (4.5m) NGVD and ended in June 2014 at 12.48 (3.8 m) NGVD (**Figure 8-21**). These levels were 0.38 ft (0.11 m) and 0.83 ft (0.25 m) lower respectively than last year, which was considered an exceptional year for nesting on the lake.

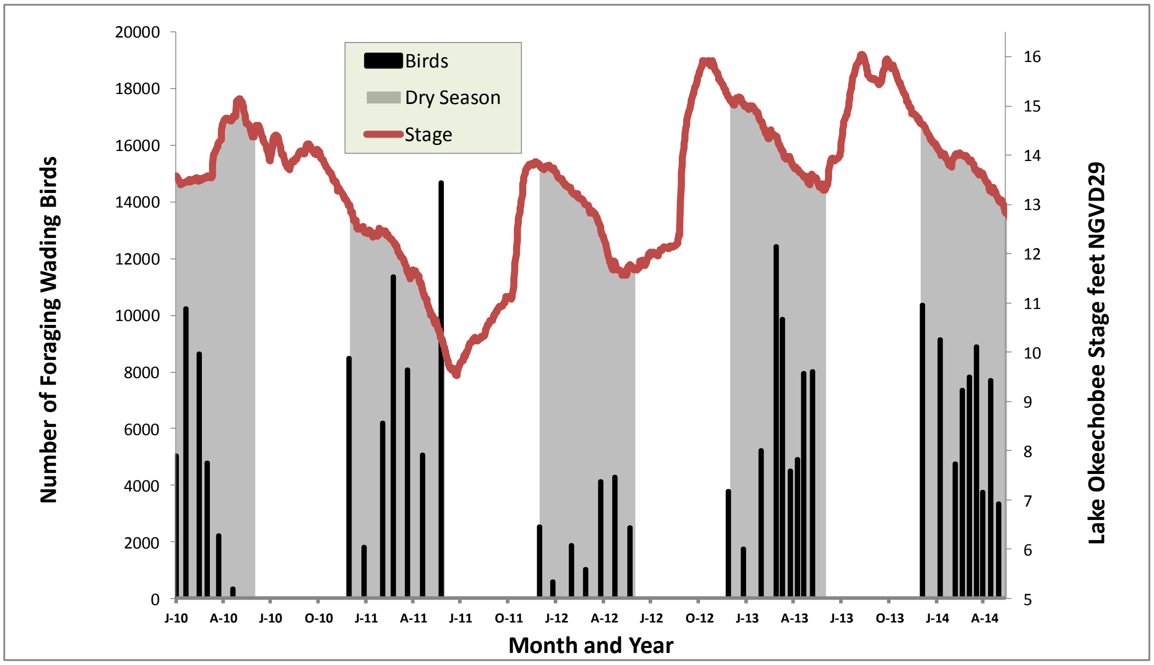


Figure 8-21. A comparison of the total number of foraging birds surveyed each month from 2010–2014 in relation to lake stage (ft NGVD). The shaded region of the graph represents the survey period which coincides with the dry season.

Throughout the season, the monthly mean wading bird flock size ranged from 177 to 415 birds (**Figures 8-21** and **8-22**). Mean monthly flock size was smaller than in 2013 and peaked in December and January; considerably earlier in the season than in the previous year, and well before the usual occurrence of peak nesting, which occurs around March. The early peak was likely the result of favorable foraging conditions early in the season relative to conditions later in the dry season. This was caused by a prolonged reversal that occurred at the end of January which increased lake stage 0.3 ft (0.1m) over a two week period followed by a recession that resulted in lower lake stages during peak nesting; limiting the amount of suitable foraging habitat available at that time. Wading bird abundance never rebounded after the reversal in January and remained low through May (3,339 birds in May 2014 as compared to 8,000 in May 2013). Generally, May abundance numbers can be considered an indicator of nesting initiated earlier in the season (Russel et al., 2002).

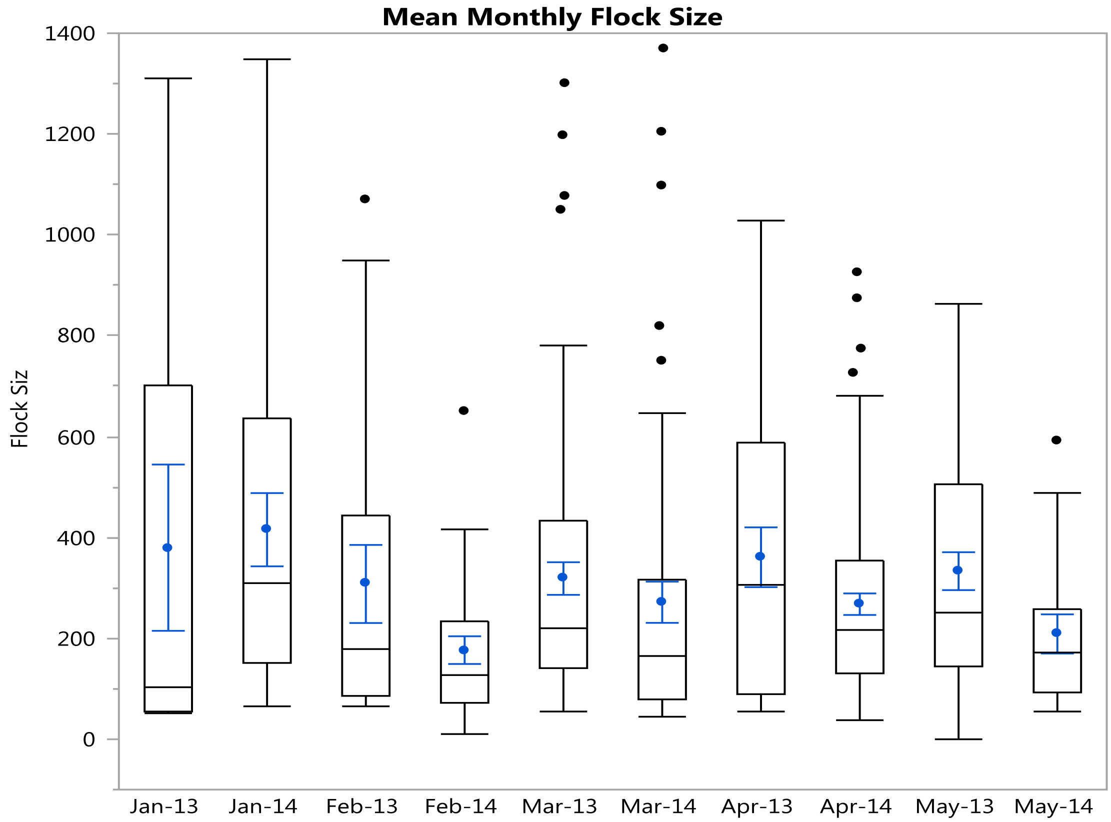


Figure 8-22. Box and whisker quartile plots in black with mean and standard error in blue comparing the monthly mean flock size for calendar years 2013-2014. Outliers represented with dots.

Weekly recession rates ranged from 0 in February to 0.14 ft in May (**Figure 8-23**). The timing of the reversal that occurred in late January and continued through mid-February may have delayed nest initiation and also caused abandonment of nests already underway. After the reversal, recession rates rebounded, but since the lake stage was low, much of the marsh was dry by mid-April, thereby limiting foraging locations to small drying ponds and areas of the marsh adjacent to the nearshore zone.

Vegetation plays an important role in both providing habitat structure and food for the production of prey species and in influencing the accessibility of prey to wading birds. Cattail, which has become increasingly dominant in the lake marsh, is a barrier to foraging by wading birds at high densities (Lantz et al., 2011). Although, hydrologic conditions are considered more of a driver for foraging success (Pierce and Gawlik, 2010) limited access to prey caused by dense cattail can supersede favorable hydrologic conditions. Observations from the past two years indicate wading birds select areas where water lily and smartweed are the dominant emergent plants with relative frequencies (31 and 19 percent, respectively) (**Figure 8-24**). These two vegetation types allow access to prey and in the case of smartweed, provide a substrate to forage from in water depths outside of the birds' normal foraging range. In contrast, cattail was dominant at only 3 percent of the foraging sites. Trends in dominant vegetation show cattail replacing water lily at a rapid rate at monitored sites (Zhang and Sharfstein, 2013).

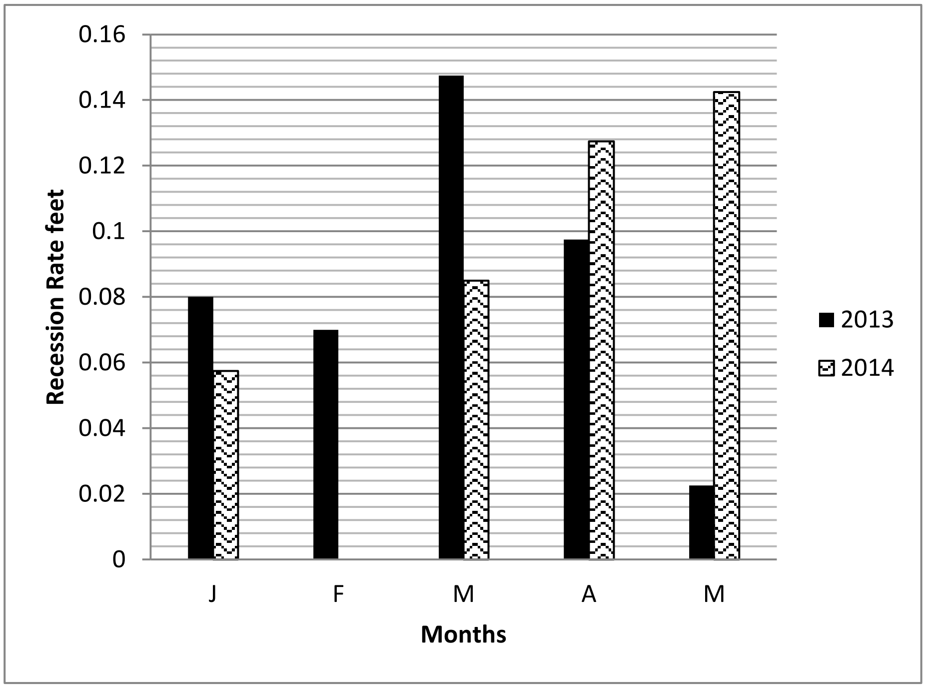


Figure 8-23. Average weekly recession rates by month for Lake Okeechobee during 2013 and 2014.

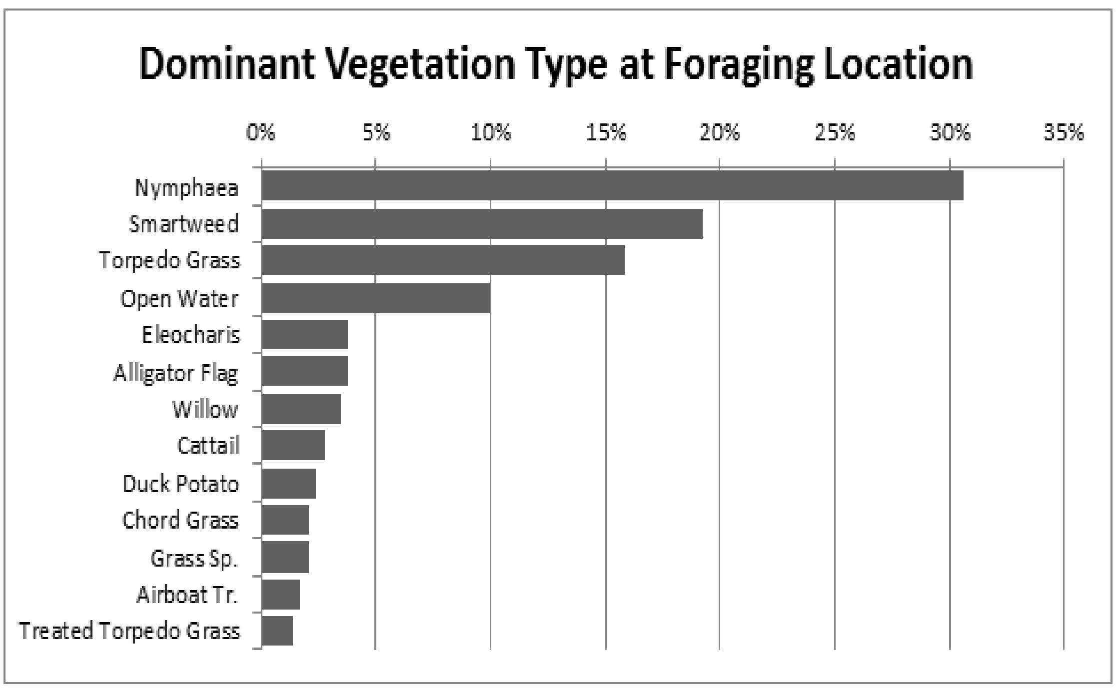


Figure 8-24. Relative frequency of the dominant vegetation present at observed foraging locations during 2013 and 2014.

Wading Bird Nesting Results

2014 Nesting effort data for wading birds on Lake Okeechobee is collected by Florida Atlantic University and will be published in the 2014 South Florida Wading Bird Report.

FISH

Lake Okeechobee's fishery is monitored annually by the Florida Fish and Wildlife Conservation Commission. They use a standardized lake-wide electrofishing protocol to monitor the near shore fishery and a lake-wide trawling protocol to monitor pelagic species.

Electrofishing

Lake wide electrofishing at 22 near shore sites during October 2013 resulted in the capture of 4,725 fish with a combined biomass of 917,391 g. Thirty-eight species were represented in the catch. Seven dominant species (more than 5 percent composition) collectively comprised 83 percent of the catch by number and were, in order of abundance: threadfin shad (*Dorosoma petenense*), bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*) (LMB), gizzard shad (*Dorosoma cepedianum*), Florida gar (*Lepisosteus platyrhincus*), and eastern mosquitofish (*Gambusia holbrooki*). Six dominant species (more than 5 percent composition) collectively comprised 82 percent of the catch by weight and were, in order of biomass: LMB, Florida gar, striped mullet (*Mugil cephalus*), bluegill, common snook (*Centropomus undecimalis*) and gizzard shad.

About 4,000 to 5,000 fish were collected annually between 2008 and 2013, however, more than 7,000 fish were collected in 2010 (**Figure 8-25**). Total fish biomass was greater than 600 kg except in 2008 when only 361 kg of fish were collected (**Figure 8-25**). The 31 percent increase in biomass from 2012 to 2013 was attributed mostly to an increase in common snook, Florida gar and striped mullet.

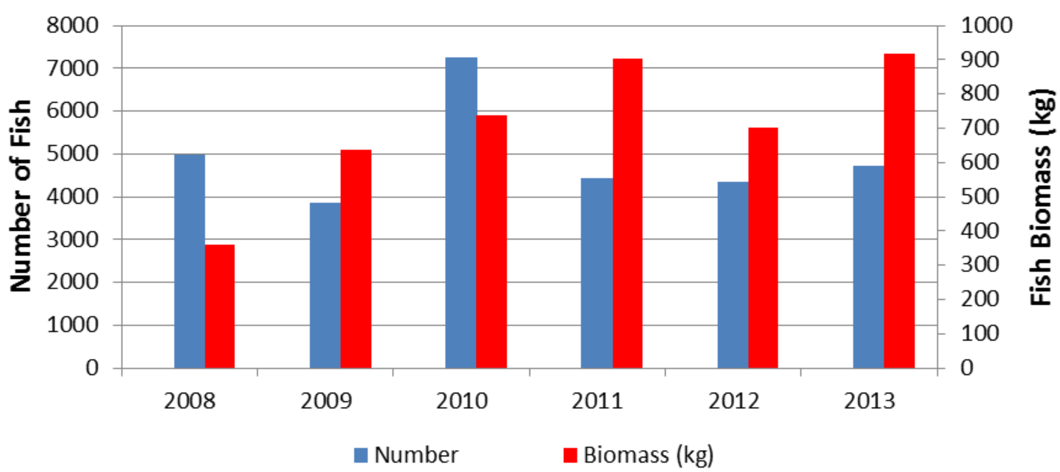


Figure 8-25. Lake-wide electrofishing data indicating the total number of fish (blue bars) and the total fish biomass (kg) (red bars) collected October 2008–2013.

Temporal changes in the fish community, as indicated by changes in proportions of selected predator and prey species, commonly occur in the near shore fishery (**Figure 8-26**). Shad species accounted for 47 percent of the total catch in 2008 while the proportion of selected piscivorous fish was generally low (**Figure 8-26**). As the proportion of several forage species declined and then remained low in 2009-2011 the proportion of the population consisting of predatory species such as largemouth bass, bluegill and redear (*Lepomis microlophus*) increased. In contrast, the portion of the total catch consisting of bluegill and redear sunfish declined the past two years while the proportion of shad increased.

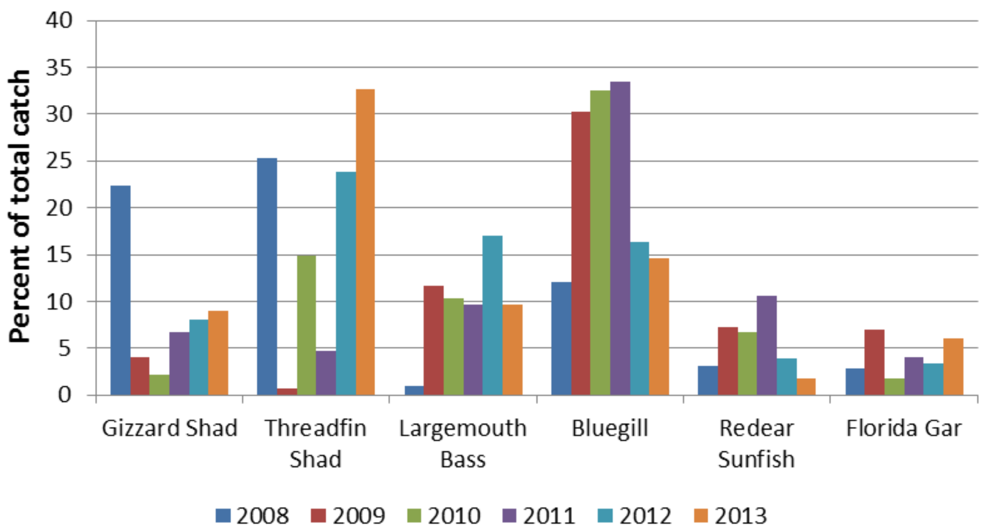


Figure 8-26. Percent of total catch of selected prey and piscivorous species collected by electrofishing from October 2008–2013.

In addition to fish abundance and biomass, the size and composition of the fish community was evaluated using catch per unit effort (CPUE) data. Low catch rates were reported for LMB, bluegill and redear sunfish in 2005-2008 following damaging hurricanes in 2004 and 2005 that affected important fish habitat and food chain links. Catch rates for largemouth bass and bluegill increased in 2009 and remained above the 2008 catch rates for the past five years. Catch rates for redear sunfish also increased in 2009–2011, but fell below the 2008 rate in 2013. Gizzard shad abundance peaked in 2008, while the abundance of many piscivorous fish was low. The catch rate for threadfin shad has been more variable, but has remained above 1 fish/minute for the past two years (**Figure 8-27**).

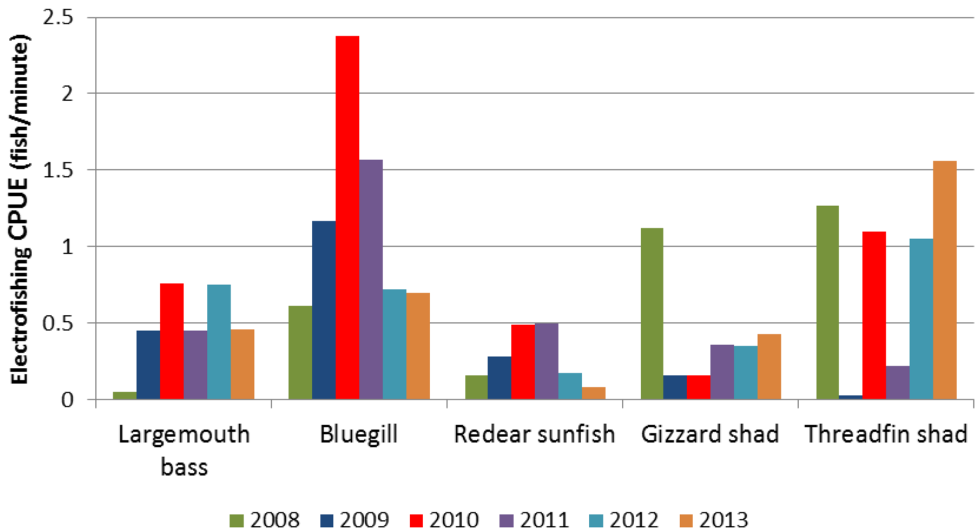


Figure 8-27. Electrofishing catch per unit effort (CPUE) values for selected species collected October 2008 – 2013.

Trawling

Lake-wide trawl sampling at 27 pelagic sites in December 2013 resulted in the capture of 4,589 fish with a combined biomass of 281,476 grams (**Figure 8-28**). Fifteen fish species were represented in the catch. Four dominant species (more than 5 percent composition) collectively comprised 91 percent of the catch by number and were, in order of abundance: threadfin shad, black crappie (*Pomoxis nigromaculatus*), bluegill and white catfish (*Ameiurus catus*). Five dominant species (more than 5 percent composition) collectively comprised 89 percent of the catch by weight and were, in order of biomass: black crappie, white catfish, Florida gar, bluegill, and threadfin shad.

As depicted in **Figure 8-29**, total pelagic fish abundance and biomass have experienced relatively small fluctuations since 2009 except for a spike in 2010 that was largely attributed to spikes in the threadfin and gizzard shad populations that year. Black crappie comprised less than 5 percent of the pelagic catch in 2008–2010. However, concurrent with improvements in water quality and increased abundance of threadfin shad, the abundance of black crappie increased and accounted for more than 25 percent of the catch in 2012 and 2013. Bluegill constituted 15-19 percent of the total catch the past four years, while 9–17 percent of the catch consisted of white catfish.

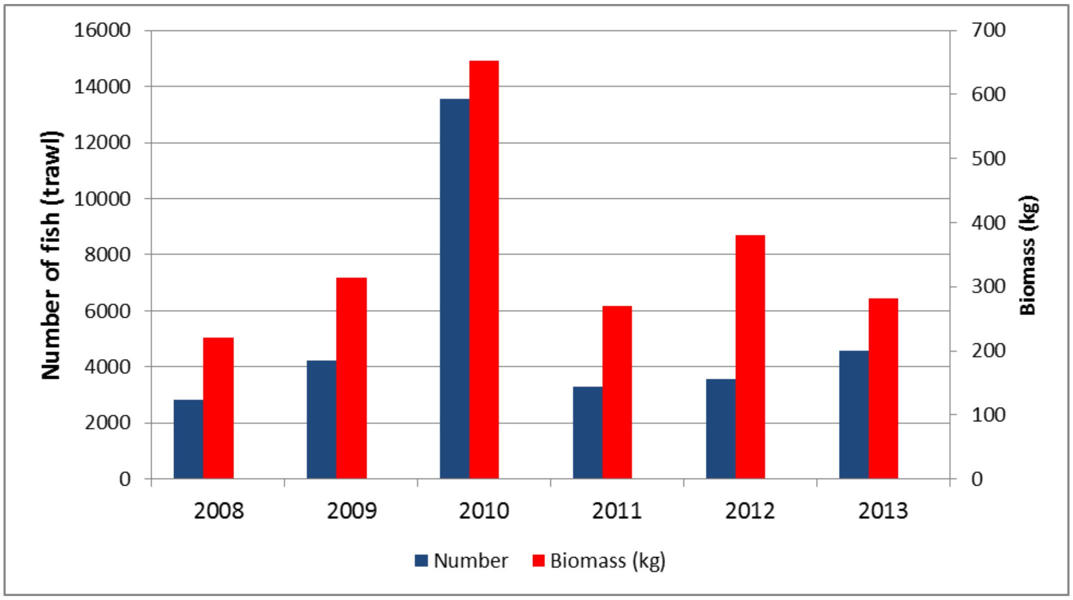


Figure 8-28. Comparison of lake-wide trawling data indicating the total number of fish (blue) and total biomass (kg) (red) collected during December 2008–2013.

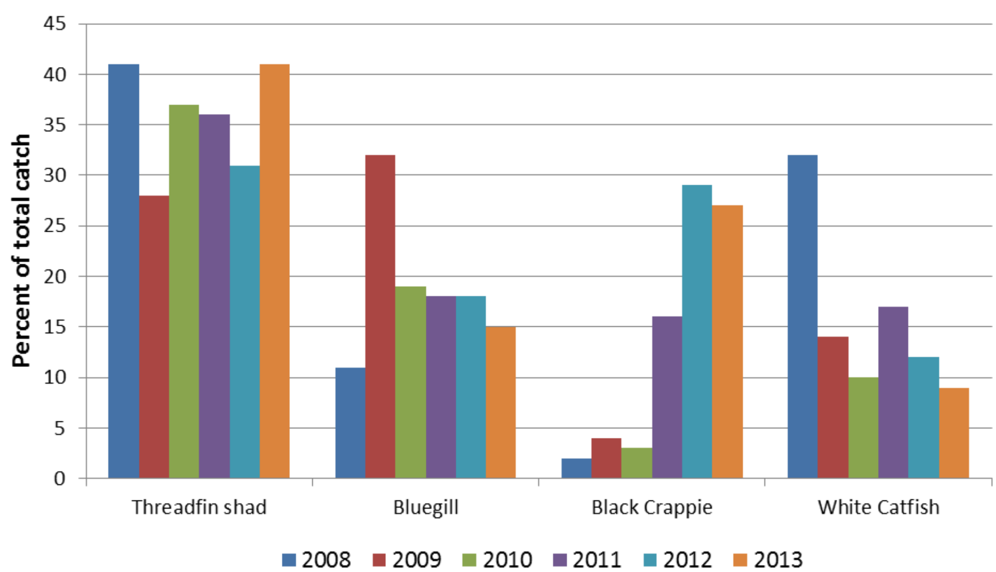


Figure 8-29. Percent of total catch of selected prey and piscivorous species collected by trawling in the pelagic region of the lake during December 2008–2013.

Sportfish Recovery

The catch rate for largemouth bass remained relatively high in 2013 and was more than eight times greater than the catch rate reported in 2008 (**Figure 8-30**). In addition to an increase in LMB abundance the bi-modal size class peaks (8–18 cm and 26–36 cm) indicate that recruitment has occurred for a number of years and that the population currently consists of both sub-adult and adult fish (**Figure 8-31**).

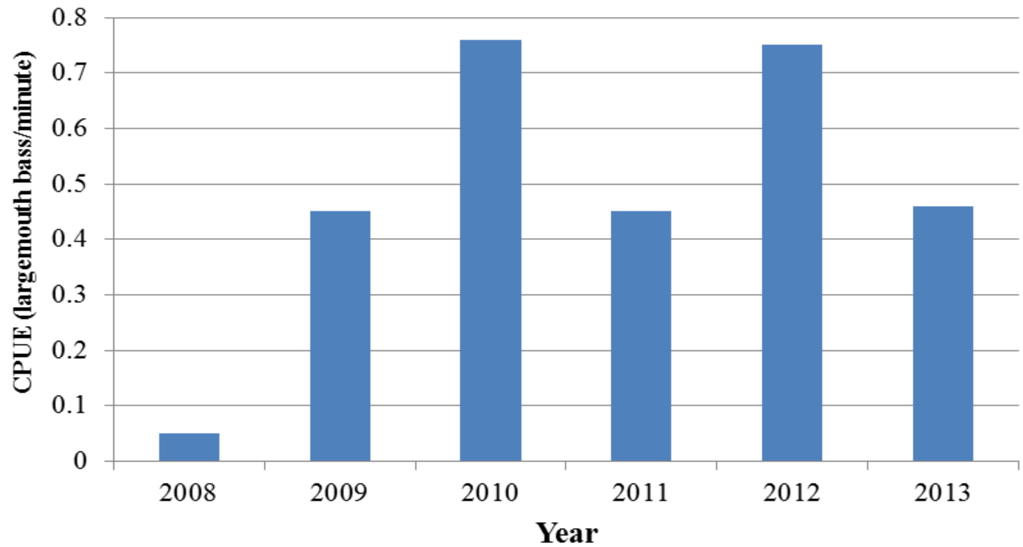


Figure 8-30. Catch rate (number of fish/minute) for largemouth bass collected by electrofishing at 22 near shore sites during October 2008–2013.

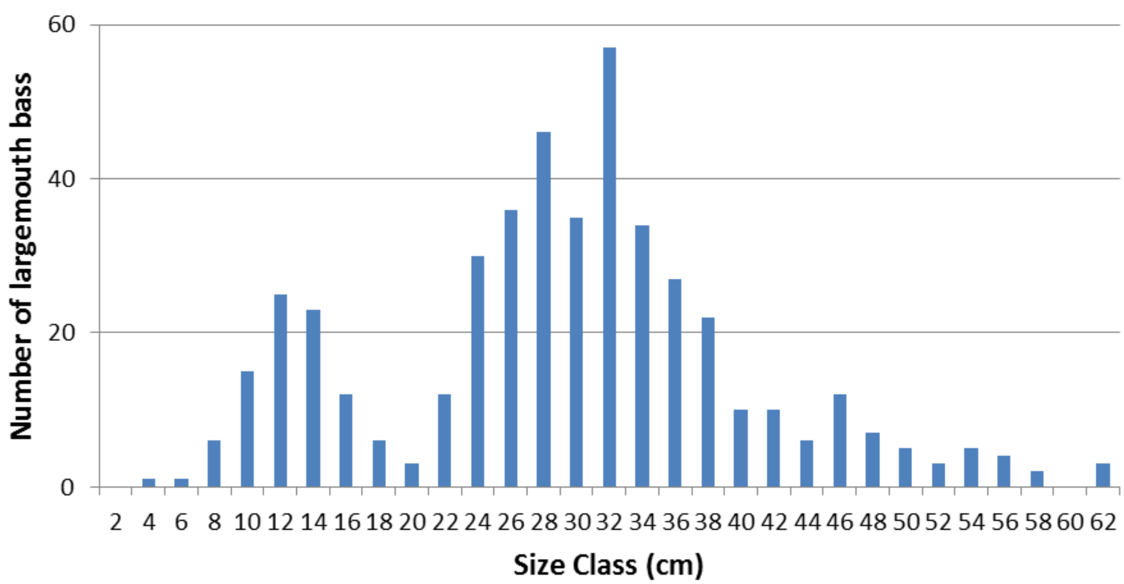


Figure 8-31. Length distribution per 2-cm size class for largemouth bass (n=458) collected by electrofishing at 22 near shore sites in October 2013.

A total of 1,179 black crappie was collected by trawl from 27 pelagic sites in 2013. This was the second most crappie collected during the past 9 years and the catch rate of 2.18 fish/minute was 18 times greater than the rate reported in 2008 (**Figure 8-32**). A majority of the crappie were young-of-the-year in the 10–14 cm range but some larger adults also were collected (**Figure 8-33**). Having such a high number of smaller black crappie is a positive indicator for the population. Catch rates are not quite at levels that were seen during the 1980s, but these rates have been increasing and the black crappie population is recovering.

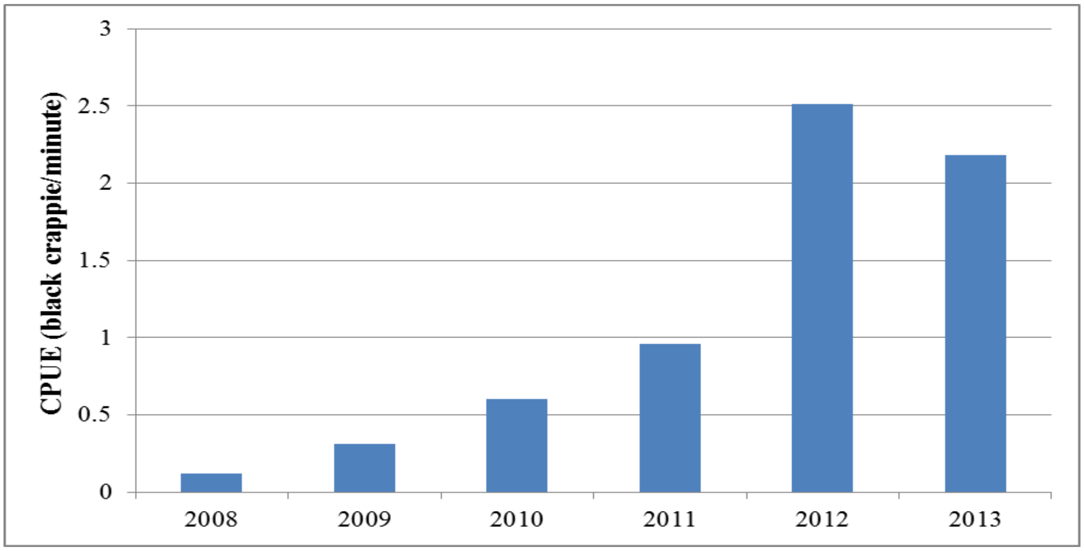


Figure 8-32. Catch rate (number of fish/minute) for black crappie collected by trawl from 27 pelagic sites during October 2008–2013.

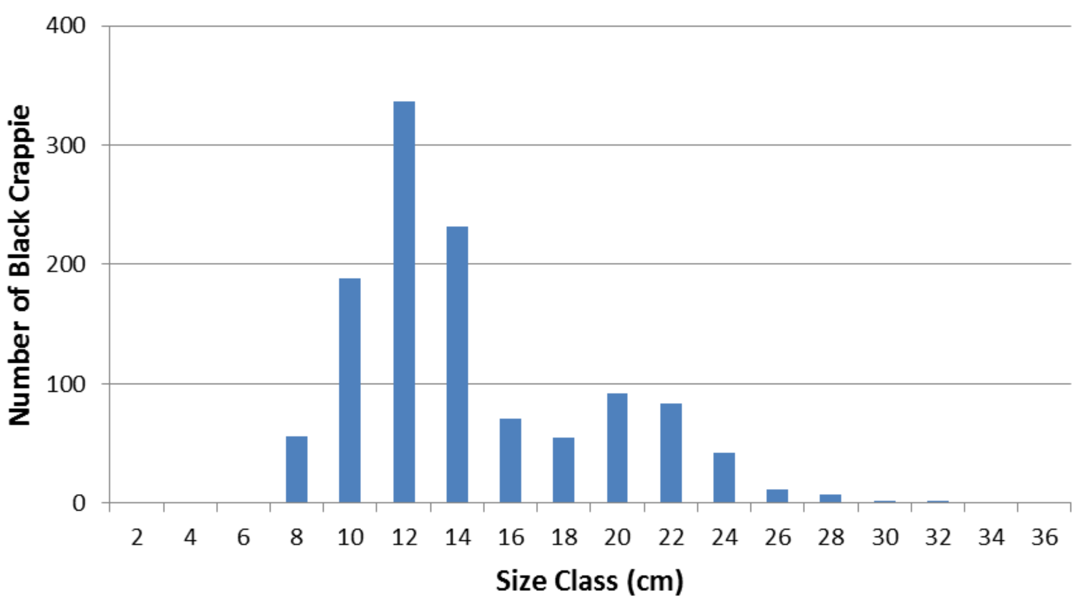


Figure 8-33. Length distribution per 2-cm size class for black crappie (n=1,179) collected in December 2013 lake wide trawl samples.

ALGAL BLOOM MONITORING

Chlorophyll *a* (Chla) concentrations, indicative of phytoplankton densities, and the toxins associated with cyanobacterial blooms have been monitored on a monthly basis at nine nearshore sites since May 2004. In May 2011 this sampling effort was combined with the long-term water quality monitoring effort conducted by the Water Quality Monitoring Section and six of the nine algal bloom monitoring sites were relocated to nearby water quality monitoring sites (**Figure 8-34**). Further details describing this relocation rationale are presented in the 2013 SFER – Volume I, Chapter 8 (Zhang and Sharfstein, 2013). It should be noted that this is at best a sentinel sampling program involving a very limited number of infrequently sampled sites. Algal blooms tend to be transient and ephemeral; therefore, the algal bloom monitoring program is not a comprehensive assessment of bloom or cyanotoxin events on Lake Okeechobee. However, over the years, it has demonstrated its ability to identify general trends in bloom and toxin occurrence. The following data for WY2014 should be interpreted with these limitations in mind. The *Satellite Imagery for Algal Bloom Monitoring* section in Appendix 8-1 of this volume describes a project that has been recently implemented in an effort to address these limitations.

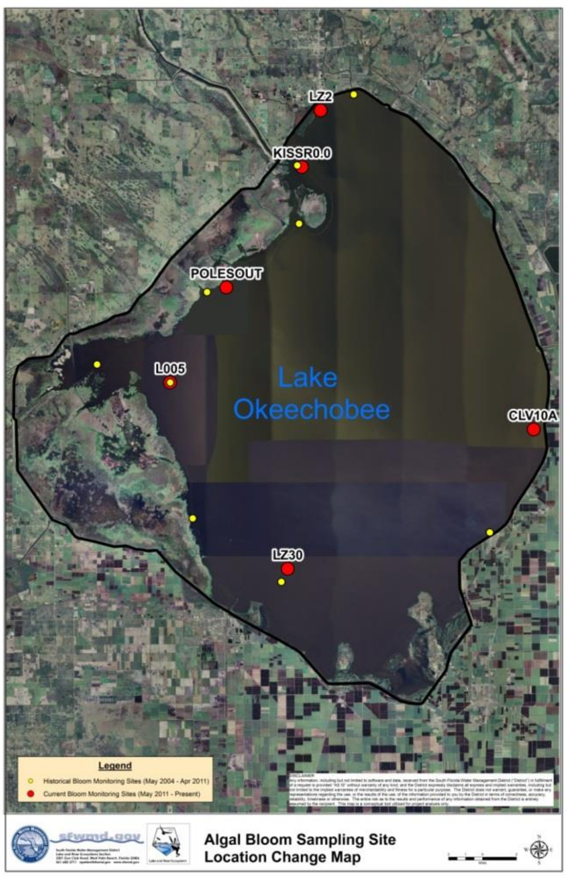


Figure 8-34. Map of algal bloom and microcystin sampling locations in Lake Okeechobee from May 2004–April 2011 (yellow dots) and from May 2011–April 2014 (red dots). Current monitoring locations are a subset of the long-term water quality monitoring network.

In general, there have been only a few instances over the past five years when either average Chla values exceeded the 40 µg/L threshold that defines algal bloom conditions or average toxin concentrations exceeded the analytical limit of detection (0.2 µg/L). During WY2014, the average Chla concentration was greater than 40 µg/L only once when in June 2013, Chla averaged 48 µg/L and ranged from 3 µg/L at LZ30 to 142 µg/L at L005 (**Figure 8-35**). However, there was a marked difference in average Chla over the last two WYs. In WY2013 the average Chla was 12.6 µg/L, ranging from 6.4–18.9 µg/L while in WY2014 the average increased to 22.5 µg/L and ranged from 9.4–47.9 µg/L. Additionally, unlike WY2013, when the only instance of a site specific bloom was detected at POLESOUT in September 2012, WY2014 had eleven instances when site specific Chla values were above 40 µg/L (**Figure 8-36**). L005 had Chla values above the threshold seven times and POLESOUT had above threshold values four times indicating that bloom conditions occurred at these two sites 58 percent and 33 percent of the time, respectively, in WY2014.

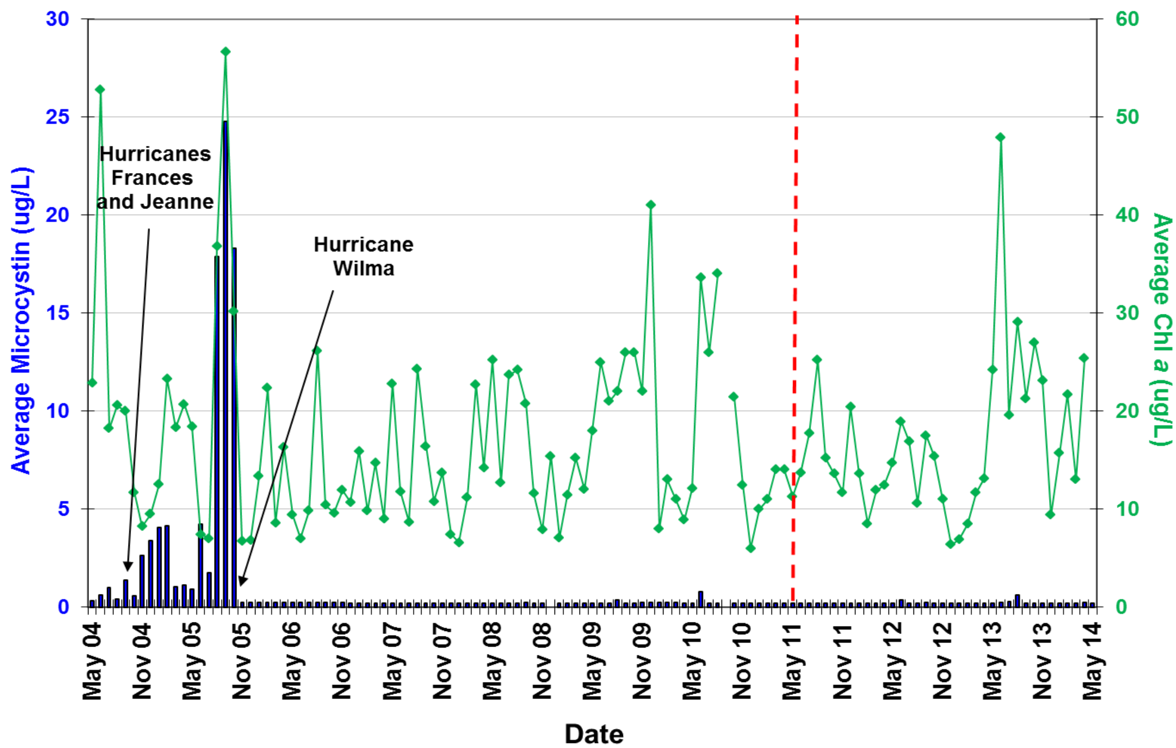


Figure 8-35. Average chlorophyll *a* (Chl*a*) and microcystin concentrations in Lake Okeechobee from May 2004 - April 2011 (9 sites) and from May 2011–April 2014 (6 sites). Dashed red line indicates when sampling locations changed. A Chla concentration of >40 µg/L indicates bloom conditions.

Further analysis suggests Chla concentrations in Lake Okeechobee were inversely correlated with dissolved inorganic nitrogen (DIN) concentrations (r = -0.59, P<0.0001) and soluble reactive phosphorus (SRP) concentrations (r = -0.59, P<0.0001), and positively correlated with total nitrogen (TN) concentrations (r= 0.52, P<0.0001). Average DIN concentrations showed a significant decrease from 0.164 mg/L (range of 0.021–0.290 mg/L) in WY2013 to 0.112 mg/L (range of 0.050–0.235 mg/L) in WY2014 as Chla concentrations increased significantly

(**Figure 8-36**). Additionally, L005 and POLESOUT, the two sites with the most bloom occurrences, also had the lowest average DIN and SRP concentrations and the highest average TN concentrations compared to the other four sites. The June 2013 Chla value of 142 µg/L at L005 suggests a moderate to severe bloom occurrence at that time. As the summer progressed, the severity of bloom conditions at this and all sites declined.

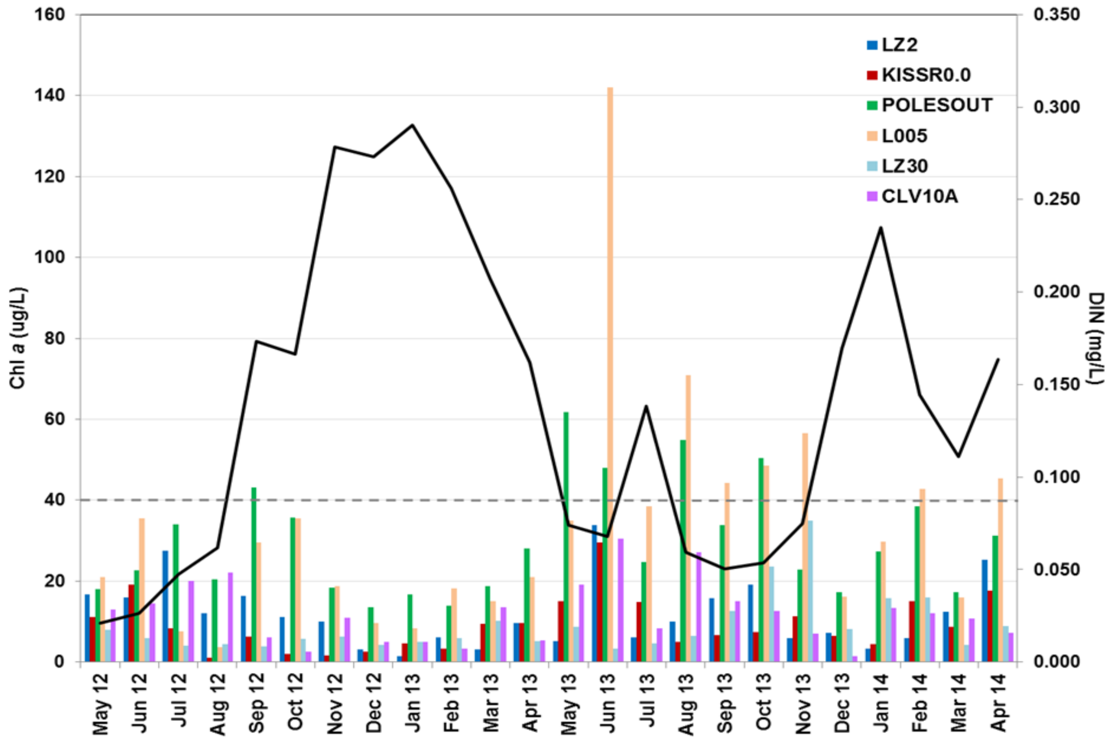


Figure 8-36. Chlorophyll *a* (Chla*)* concentrations at each site (bars) and average monthly Dissolved Inorganic Nitrogen (DIN) concentrations (solid line) for WY2013 and WY2014. Dashed line represents threshold Chla concentration of >40 µg/L indicative of bloom conditions.

Microcystin concentrations were not significantly different (P >0.05) between the two water years, with average values of 0.22 µg/L and 0.26 µg/L in WY2013 and WY2014, respectively. The highest value during the two WYs was reported at CLV10A in August 2013 where toxin concentrations reached 2.20 µg/L. In contrast there were only two instances when toxin concentrations were greater than the analytical limit of detection (0.2 µg/L) in WY2013, compared to eight instances when the detection limit was exceeded in WY2014 (**Figure 8-37**). Of these eight instances, all were during the summer months when Chla was highest. Even though Chla values were highest at L005 and POLESOUT during summer 2013, the two highest toxin concentrations during that time were at CLV10A followed by KISSR0.0, suggesting that there were blooms at these sites just prior to sampling. It is not clear what factors influence microcystin production in Lake Okeechobee as correlations were significant, but showed very weak relationships with flows from the Kissimmee River (r=0.26, P=0.0020), total inflows (r=0.25, P=0.0020) and temperature (r=0.22, P=0.0094). In other Florida sub-tropical lakes, temperature does influence microcystin concentrations with the majority of elevated concentrations (≥1.0 µg/L) occurring from May to November (Bigham et al., 2009). This pattern also has also been seen in Lake Okeechobee over the past four to five years (**Figure 8-35**).

Although microcystin concentrations increased slightly over the past two years, the toxin values were all well below the recreational guidance value of 20 µg/L for activities in direct contact with water, and 100 µg/L for activities having indirect contact with water (Chorus and. Bartram, 1999). These guidance values represent a moderate probability of adverse health effects for humans. Over the past five years, the toxin values during the summer months have been low given the relatively high Chla values, especially during isolated blooms. It has been suggested that shallow, eutrophic, sub-tropical systems have low microcystin to chlorophyll ratios which may explain the low toxin values. Additional research is needed to determine the reason for these results. Currently, light conditions in the lake are favorable for surface bloom formation, but only minor isolated surface blooms have been detected since the prolific blue-green algal blooms that occurred in summer 2005.

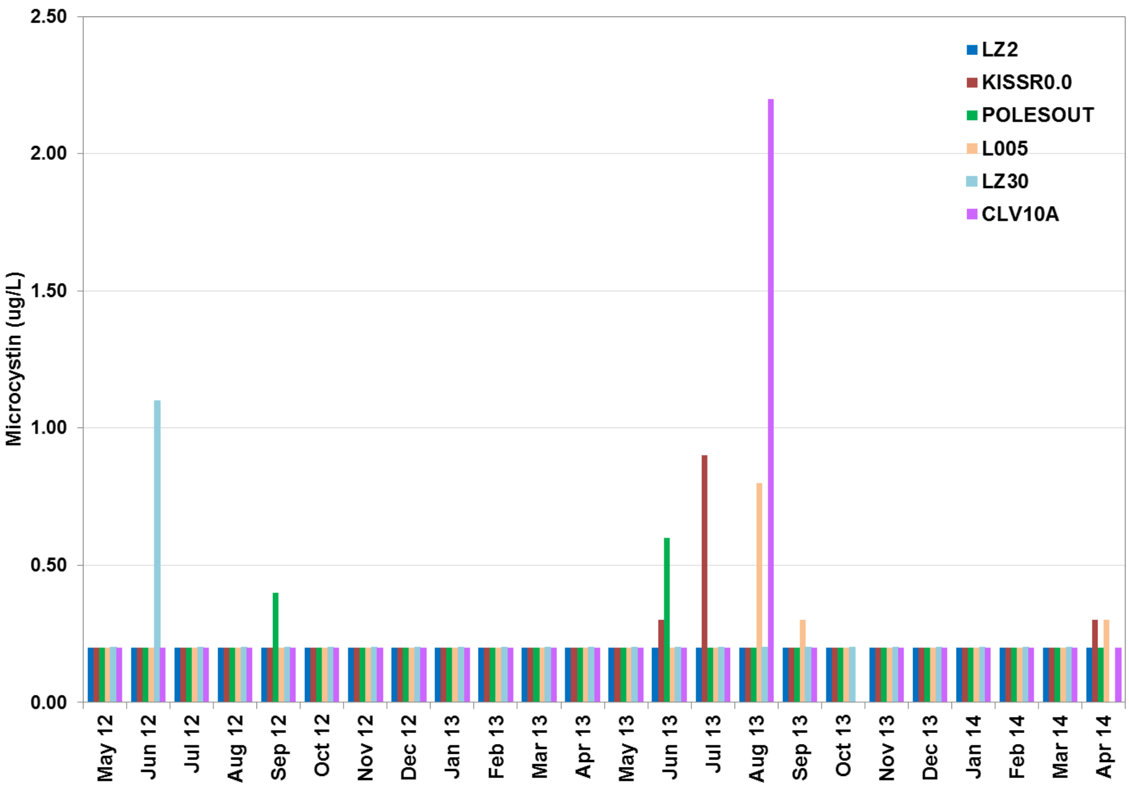


Figure 8-37. Microcystin concentrations at each site during WY2013 and WY2014. [Note: The analytical detection limit is 0.2 µg/L.]

MODELING, RESEARCH, DEMONSTRATION AND ASSESSMENT PROJECTS

The District, in cooperation with the FDACS, FDEP, UF/IFAS, and other agencies and interested parties, has implemented a comprehensive research and assessment program for the lake and its watershed. Fifteen research, demonstration, and assessment projects were under way or completed in WY2014, and two are anticipated to begin in WY2015 (**Table 8-13**). Appendix 8-1 of this volume provides more information on projects in Table 8-13 that have an asterisk following the project name. Additionally, more information on some of the projects can be found on the District's website at www.sfwmd.gov/okeechobee.

Table 8-13. Status of Lake Okeechobee Watershed and lake modeling, demonstration projects, research, and assessment projects during WY2014.

Project Name (Investigator)	Description, Major Objectives and Results	Status
Nutrient Budget Analyses for Tributaries in Lake Tohopekaliga (Toho) and East Lake Toho Drainage Basins (SFWMD)	A watershed focused nutrient budget study completed in 2013 identified relative contributions of P from land uses and related sources (JGH Engineering 2013). PN-Budget, a nutrient budget tool, also was developed to estimate the amount of P that enters, exits or remains within a study area, as well as P load and concentrations from all major contributing basins of the Upper Kissimmee Chain-of-Lakes. District staff applied the PN-Budget Tool to East Lake Toho and Lake Toho drainage areas to estimate the runoff and loads from major and minor tributaries for the period of 2006 to 2010. These were tabulated to estimate both the major and minor inputs to these lakes. These PN-Budget Tool tabulations were compared to the estimates from the lake nutrient budget estimates for the same period. While most values are within similar ranges for flows and loads, future efforts to include measurement of key minor tributaries should narrow the differences between the two estimates. A summary of the comparison result is presented in Chapter 9 of this volume.	Completed
Lake Okeechobee Water Quality Model Recalibration* SFWMD)	The Lake Okeechobee Water Quality Model was developed to improve our understanding of internal nutrient, specifically TP, cycling within the lake and to assess lake-wide responses to various management alternatives. The model, previously calibrated and validated to hydro-meteorological and monitoring data from 1983 to 2000, was recalibrated to data through 2012 to capture a series of extreme hydro-meteorological events that occurred from 2005 to 2008.	Completed
Apple Snail Stocking Experiments* (SFWMD)	As an adjunct to ongoing experiments designed to identify a cost-effective method for producing large numbers of native apple snails eggs or juveniles for stock enhancement efforts in Lake Okeechobee and other water bodies that constitute critical habitat for the federally endangered Everglade snail kite (*Rostrhamus sociabilis plumbeus*), apple snail stocking experiments in large-scale enclosures open to natural predation were initiated. Results indicate that it is possible to reliably establish populations of native apple snails from hatchery-produced animals stocked at relatively low densities. The hatchery facility is in standby mode and could be re-started and scaled up on relatively short notice.	Completed
Emergent Vegetation Decomposition and Nutrient Cycling Rates* (SFWMD)	Major differences in nutrient cycling occur in Lake Okeechobee at low versus high water levels (James and Havens, 2005). Periodically, rapid increases in lake levels occur as a result of extreme weather events such as hurricanes and tropical storms. Increased waves and turbulence associated with these events uproot and tear emergent vegetation leading to significant amounts of fresh litter. As this fresh litter decomposes, the nutrients they contain are likely introduced to the water column contributing to the increased nutrient concentrations observed at higher water levels. To understand how plant decomposition is affected by such rapid water increases, and how this decomposition contributes to nutrient dynamics under high water conditions, this study tested a standard method to measure fresh plant decomposition under both wet and dry conditions. This information will increase the reliability of predictions from the Lake Okeechobee Water Quality Model (James et al., 2005; James, 2013) and give a better understanding of the effects of rapid increases in lake level on the water quality of Lake Okeechobee.	Field work completed

Table 8-13. Continued.

Project Name (Investigator)	Description, Major Objectives and Results	Status
Permeable Reactive Barrier (PRB) Technology [University of Florida/Institute of Food and Agricultural Sciences (UF/IFAS)]	The components of a permeable reactive barrier (PRB) include a trench dug perpendicular to the groundwater flow direction and to a depth appropriate to the groundwater contamination problem of interest. The trench generally is filled with sorbents such as water treatment residuals (WTRs), aluminum and iron oxide compounds, and low cost materials available locally. For this project aluminum-base water treatment residuals (Al-WTRs) were tested for the interception and long-term sequestration of soluble subsurface-P in the Lake Okeechobee Watershed. In April 2011, two buried-wall PRBs were installed in the high intensive area of a former dairy site (presently Candler Ranch). Monitoring results at the Candler Ranch site were completed in January 2012, and the results showed that the PRB was functioning chemically as designed, but the site hydrology was not suitable for PRB implementation. A second PRB was installed in August 2012 at Butler Oaks Ranch in Highlands County to better evaluate the effectiveness of this technology. Monitoring at the Butler Oaks Ranch was completed in October 2013 and a final report was submitted by UF in January 2014. Results from the Butler Oaks PRB showed better hydrologic properties, however, low SRP concentrations in the groundwater proved difficult to satisfactory test this technology. In summary, the two field sites each proved a different limiting factor in the use of Al-WTR installed in a PRB system as an effective sorbent for SRP in groundwater. Despite high levels of SRP, Candler Ranch did not have hydrologic conditions necessary for optimal PRB efficiency. Butler Oaks had better hydrologic properties but the SRP concentrations in the groundwater were too low to remove a sufficient amount of P. No further testing is planned.	Completed
New Treatment Technologies (SFWMD)	Completed the evaluation of several products/technologies and documented the results in District Technical Publication WR-2013-03: Alternative Treatment Technologies Evaluations, September 2011–June 2013 (SFWMD, 2013). In summary, the products/technologies represent only a very small subset of products and technologies that are available, and the program was not intended to provide a systematic cross-comparison of technologies. Not all of the products/technologies are available at a commercial scale, and this testing represented screening level studies. Direct comparisons are difficult to make among technologies due to different water sources, etc., and since all tests were of short duration and limited scope, they must be regarded as preliminary efforts to characterize the treatment potential of each technology to reduce P or N concentrations. The assessment of treatment performance for each technology was based on a comparison of before application versus after application constituent levels, and all technologies were able to reduce total phosphorus and total nitrogen to varying degrees	Completed
Lake Okeechobee Littoral Marsh Aquatic Plant Communities Food Web Characteristics* (SFWMD)	The establishment of marsh EAV habitat in formerly SAV nearshore areas may have resulted in a significantly modified nearshore food web. However, relatively little data have been collected to document changes among the littoral food web trophic levels. To facilitate habitat utilization comparisons among three of the dominant littoral marsh aquatic plant habitats, throw-trap sampling is being conducted to collect data on water quality and on ecological attributes including fish, macroinvertebrates, periphyton, phytoplankton and zooplankton (plankton).	Ongoing
Wading Bird Foraging Prediction Model* (SFWMD)	This project involves developing an ecological model to better understand and predict how wading birds respond to environmental and climatological changes in Lake Okeechobee. Ecological models that predict outcomes of such changes can be useful tools in understanding the effects of management decisions and in evaluating restoration strategies. There may be limitations to fully understanding cause-and-effect relationships since local and regional conditions outside of the lake can influence responses on the lake. However, completing a Lake Okeechobee model will bring us one step closer to better understanding wading bird population ecology in the Greater Everglades watershed.	Ongoing

Table 8-13. Continued.

Project Name (Investigator)	Description, Major Objectives and Results	Status
Evaluation and Development of Alternative Monitoring Techniques* (SFWMD)	The District is evaluating or helping to develop new methods for monitoring ecological parameters in Lake Okeechobee. These include refining a satellite imagery tool for use of algal bloom monitoring on Lake Okeechobee, merging and interpolating existing bathymetric data sets to create a 5' digital elevation model of Lake Okeechobee using Lowrance sonar technology to improve SAV monitoring, and investigating the possibility of incorporating unmanned aircraft systems for emergent vegetation, algal bloom and wading bird surveys	Ongoing
Evaluation of the Potential Ecological Benefits To Lake Okeechobee of Various Volumes of Storage* (SFWMD)	Performance measures relating submerged aquatic vegetation, wading bird foraging, periphyton, fisheries, and cyanobacterial blooms to Lake Okeechobee water levels were developed based on long term monitoring data sets. These performance measures are being used to evaluate potential ecological benefits, attributable to storage volumes over the range of 500,000 to 4 million acre feet using the monthly time step model, Reservoir Operations (RESOPS). Performance measures are developed and model runs completed. Current efforts are directed at analyzing and interpreting the information generated by this effort. This study will inform the Storage Needs North of the Lake Analysis described below.	Ongoing
PN-Budget Tool Applications to Tributaries in the Lake Kissimmee Drainage Basin (SFWMD)	The overall goal of this project is to apply the PN-Budget tool to the Upper Kissimmee Sub-watershed to identify the hydrologic and loading data needed to develop a nutrient budget for the Upper Chain of Lakes. PN-Budget tool can be used to evaluate various P control programs to maximize water quality improvements from a drainage area. Specific objectives are to (1) select the area of interest (AOI) based on the reaches and monitoring locations that need to be studied, (2) compare the AOI results with the available monitoring data and adjust the model inputs if needed; and (3) obtain nutrient loading data needed for the lake nutrient budget analysis. The project is scheduled to be completed by May 2015.	Ongoing
Lake Okeechobee Pre-drainage Characterization (TBD)	The Lake Okeechobee Pre-drainage Characterization Project uses the Watershed Assessment Model (WAM; SWET, 2001a and 2011b) to compare existing hydrologic conditions with historical conditions that existed before significant human influences took place (i.e., pre-drainage 1850s). Pertinent literature describing pre-drainage conditions was reviewed and relevant data incorporated into WAM in preparation for the pre-drainage condition model runs. The coordinating agencies determined that before proceeding with comparing pre-drainage and existing hydrologic conditions on all five sub-watersheds, the WAM Sensitivity and Uncertainty analysis should be completed. During the sensitivity and uncertainty analyses, WAM will be recalibrated resulting in increased confidence of the modeled pre-drainage and existing hydrologic conditions.	Ongoing
The Fisheating Creek Feasibility Study (SFWMD)	The Fisheating Creek Feasibility Study involves formulation, evaluation, and selection of the most appropriate mix of storage and water quality features to improve hydrology and water quality in the Fisheating Creek Sub-watershed. Planning targets for achieving surface water storage and quality improvements (TP load reduction) were also established through analyzing pre-drainage and existing conditions outputs from WAM simulations in close coordination with stakeholders and other agencies. The next step is to locate conceptual water quality and storage features. The Natural Resources Conservation Service is currently developing the Fisheating Creek Special Wetland Reserve Project (WRP), which involves large tracts of lands located north of State Road 70 that account for approximately 18 percent of the total sub-watershed area. It is important to account for all upcoming hydrologic improvement projects in the Fisheating Creek Watershed in order to adequately characterize the additional features that will be needed to meet study goals. Postponing the study until WRP details are available and incorporating them into the FEC FS will allow this to occur. It is anticipated that the necessary data will be available in 2015, at which time the District may resume the project in FY2016 once this information is available and after WAM enhancements are completed under the Lake Okeechobee Pre-drainage Characterization project mentioned above.	Ongoing

Table 8-13. Continued.

Project Name (Investigator)	Description, Major Objectives and Results	Status
Development of Markers to Identify Nutrient Sources Impacting Florida's Surface Water Bodies (FDEP)	The main purpose of this study was to investigate and develop potential analytical marker(s) to use as tools in the identification of different sources of nutrients [primarily nitrogen (N) and phosphorus (P)] to Florida's waters. This study conducted a large assessment of N and P at water reuse plants to estimate potential nutrient mass loading from municipal waste reuse plants in Florida. A short-list of differentiation markers was developed to determine their ability to identify nutrient sources from municipal reclaimed water, stormwater, and septic tanks. The short-listed markers were then put through a series of both "bench-top" and field analyses and a "reconnaissance tool" was constructed to assess nutrient loading to water bodies. Sucralose was identified as a successful environmentally conservative marker specific to wastewater sources. The use of a gadolinium (Gd) anomaly/sucrose ratio showed the potential to differentiate between reuse effluent and septic tank sources; however, further research is needed to validate this technique. Overall, the study proposes a potentially useful assessment strategy for determining nutrient sources to Florida's waters. These promising tools and strategy, however, remain in a conceptual stage until additional studies build upon the initial findings. Ongoing investigations to build upon the initial report are under way and consist of field demonstration work in the Gordon River Watershed (Collier County) in Southwest Florida. This current effort is part of a FDEP nutrient source tracking study in the Everglades West Coast Basin and also includes some focused literature review as well as stakeholder outreach to work toward the continued development of robust markers to identify nutrient sources in Florida's waters. FDEP are currently working on obtaining a contractor to continue this work in 2014.	Initial Report Complete; Follow-up Studies Ongoing
Evaluation of Storage and Water Quality Alternatives at the Grassy Island and Brady Ranch Properties (SFWMD)	The objective of this study is evaluate water quality and storage options for the District's Taylor Creek/Grassy Island and Brady Ranch properties located in the Taylor Creek/Nubbin Slough Sub-watershed. The District initiated hydrologic modeling efforts in 2014.	Ongoing
WAM Sensitivity and Uncertainty Analysis (FDACS /SFWMD/ FDEP)	This project involves implementing the two remaining recommendations for enhancing WAM that are included in the "Peer Review of the Watershed Assessment Model (WAM) (Graham et al., 2009). The two recommendations for enhancing WAM are the performance of a sensitivity analysis and an uncertainty analysis. All the other five recommendations by the peer review panel have been completed. As part of implementing the sensitivity and uncertainty analyses, WAM will be recalibrated resulting in increased confidence of the model's results, it will add a margin-of-safety value derived through a formal uncertainty analysis and the sensitivity analysis will allow us to identify the model's most sensitive parameters which can then be refined as appropriate,	Anticipated to start in FY2015
Storage Needs North of the Lake Analysis (SFWMD)	The purpose of this project is to re-assess total storage north of the lake, identify storage needs by sub-watershed and determine the best tools to accomplish storage goals. Key tasks in this analysis are anticipated to include a technology sub-watershed suitability analysis and a technology cost effectiveness analysis. Storage features being considered are deep and shallow storage, ASR and Dispersed Water Management.	Ongoing

* Additional information on this project is available in Appendix 8-1 of this volume.

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